## SWITCHMODETM Pulse Width Modulation Control Circuit

The TL494 is a fixed frequency, pulse width modulation control circuit designed primarily for SWITCHMODE power supply control.

- Complete Pulse Width Modulation Control Circuitry
- On-Chip Oscillator with Master or Slave Operation
- On-Chip Error Amplifiers
- On-Chip 5.0 V Reference
- Adjustable Deadtime Control
- Uncommitted Output Transistors Rated to 500 mA Source or Sink
- Output Control for Push-Pull or Single-Ended Operation
- Undervoltage Lockout

unless otherwise noted.)

| Rating | Symbol | TL494C | TL494I | Unit |
| :--- | :---: | :---: | :---: | :---: |
| Power Supply Voltage | $\mathrm{V}_{\mathrm{CC}}$ | 42 | V |  |
| Collector Output Voltage | $\mathrm{V}_{\mathrm{C} 1}$, <br> $\mathrm{V}_{\mathrm{C} 2}$ | 42 | V |  |
| Collector Output Current <br> (Each transistor) (Note 1) | $\mathrm{I}_{\mathrm{C} 1}, \mathrm{I}_{\mathrm{C} 2}$ | 500 | mA |  |
| Amplifier Input Voltage Range | $\mathrm{V}_{\mathrm{IR}}$ | -0.3 to +42 | V |  |
| Power Dissipation @ $\mathrm{T}_{\mathrm{A}} \leq 45^{\circ} \mathrm{C}$ | $\mathrm{P}_{\mathrm{D}}$ | 1000 | mW |  |
| Thermal Resistance, <br> Junction-to-Ambient | $\mathrm{R}_{\theta \mathrm{JA}}$ | 80 | ${ }^{\circ} \mathrm{C} / \mathrm{W}$ |  |
| Operating Junction Temperature | $\mathrm{T}_{\mathrm{J}}$ | 125 | ${ }^{\circ} \mathrm{C}$ |  |
| Storage Temperature Range | $\mathrm{T}_{\text {stg }}$ | -55 to +125 | ${ }^{\circ} \mathrm{C}$ |  |
| Operating Ambient Temperature Range <br> $\mathrm{TL494C}$ | $\mathrm{~T}_{\mathrm{A}}$ | 0 to +70 | ${ }^{\circ} \mathrm{C}$ |  |
| TL494I | -25 to +85 |  |  |  |
| Derating Ambient Temperature | $\mathrm{T}_{\mathrm{A}}$ | 45 | ${ }^{\circ} \mathrm{C}$ |  |

NOTE: 1. Maximum thermal limits must be observed.

## SWITCHMODE PULSE WIDTH MODULATION CONTROL CIRCUIT

## SEMICONDUCTOR

 TECHNICAL DATA

ORDERING INFORMATION

| Device | Operating <br> Temperature Range | Package |
| :--- | :---: | :---: |
| TL494CD | $\mathrm{T}_{\mathrm{A}}=0^{\circ}$ to $+70^{\circ} \mathrm{C}$ | SO- 16 |
| $\mathrm{TL494CN}$ |  | Plastic |
| TL494IN | $\mathrm{T}_{\mathrm{A}}=-25^{\circ}$ to $+85^{\circ} \mathrm{C}$ | Plastic |

## RECOMMENDED OPERATING CONDITIONS

| Characteristics | Symbol | Min | Typ | Max | Unit |
| :--- | :---: | :---: | :---: | :---: | :---: |
| Power Supply Voltage | $\mathrm{V}_{\mathrm{C} C}$ | 7.0 | 15 | 40 | V |
| Collector Output Voltage | $\mathrm{V}_{\mathrm{C} 1}, \mathrm{~V}_{\mathrm{C} 2}$ | - | 30 | 40 | V |
| Collector Output Current (Each transistor) | $\mathrm{I}_{\mathrm{C} 1}, \mathrm{I}_{\mathrm{C} 2}$ | - | - | 200 | mA |
| Amplified Input Voltage | $\mathrm{V}_{\mathrm{in}}$ | -0.3 | - | $\mathrm{V}_{\mathrm{CC}}-2.0$ | V |
| Current Into Feedback Terminal | $\mathrm{I}_{\mathrm{fb}}$ | - | - | 0.3 | mA |
| Reference Output Current | $\mathrm{I}_{\text {ref }}$ | - | - | 10 | mA |
| Timing Resistor | $\mathrm{R}_{\mathrm{T}}$ | 1.8 | 30 | 500 | $\mathrm{k} \Omega$ |
| Timing Capacitor | $\mathrm{C}_{\mathrm{T}}$ | 0.0047 | 0.001 | 10 | $\mu \mathrm{~F}$ |
| Oscillator Frequency | $\mathrm{f}_{\mathrm{osc}}$ | 1.0 | 40 | 200 | kHz |

ELECTRICAL CHARACTERISTICS ( $\mathrm{V}_{\mathrm{CC}}=15 \mathrm{~V}, \mathrm{C}_{\mathrm{T}}=0.01 \mu \mathrm{~F}, \mathrm{R}_{\mathrm{T}}=12 \mathrm{k} \Omega$, unless otherwise noted.)
For typical values $T_{A}=25^{\circ} \mathrm{C}$, for $\mathrm{min} / \mathrm{max}$ values $\mathrm{T}_{\mathrm{A}}$ is the operating ambient temperature range that applies, unless otherwise noted.

| Characteristics | Symbol | Min | Typ | Max | Unit |
| :---: | :---: | :---: | :---: | :---: | :---: |
| REFERENCE SECTION |  |  |  |  |  |
| Reference Voltage ( $\mathrm{l} \mathrm{O}=1.0 \mathrm{~mA}$ ) | $V_{\text {ref }}$ | 4.75 | 5.0 | 5.25 | V |
| Line Regulation ( $\mathrm{V}_{\mathrm{CC}}=7.0 \mathrm{~V}$ to 40 V ) | Regline | - | 2.0 | 25 | mV |
| Load Regulation ( $\mathrm{l} \mathrm{O}=1.0 \mathrm{~mA}$ to 10 mA ) | Regload | - | 3.0 | 15 | mV |
| Short Circuit Output Current ( $\mathrm{V}_{\text {ref }}=0 \mathrm{~V}$ ) | ISC | 15 | 35 | 75 | mA |

OUTPUT SECTION

| Collector Off-State Current $\left(\mathrm{V}_{\mathrm{CC}}=40 \mathrm{~V}, \mathrm{~V}_{\mathrm{CE}}=40 \mathrm{~V}\right)$ | ${ }^{1} \mathrm{C}$ (off) | - | 2.0 | 100 | $\mu \mathrm{A}$ |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Emitter Off-State Current $\left.\mathrm{V}_{\mathrm{CC}}=40 \mathrm{~V}, \mathrm{~V}_{\mathrm{C}}=40 \mathrm{~V}, \mathrm{~V}_{\mathrm{E}}=0 \mathrm{~V}\right)$ | ${ }^{\text {I }}$ (off) | - | - | -100 | $\mu \mathrm{A}$ |
| Collector-Emitter Saturation Voltage (Note 2) Common-Emitter ( $\mathrm{V}_{\mathrm{E}}=0 \mathrm{~V}, \mathrm{I}_{\mathrm{C}}=200 \mathrm{~mA}$ ) Emitter-Follower $\left(\mathrm{V}_{\mathrm{C}}=15 \mathrm{~V}, \mathrm{I}_{\mathrm{E}}=-200 \mathrm{~mA}\right)$ | $V_{\text {sat }}(C)$ <br> $\mathrm{V}_{\text {sat }}(\mathrm{E})$ | - | $\begin{aligned} & 1.1 \\ & 1.5 \end{aligned}$ | $\begin{aligned} & 1.3 \\ & 2.5 \end{aligned}$ | V |
| Output Control Pin Current Low State ( $\mathrm{V}_{\mathrm{OC}} \leq 0.4 \mathrm{~V}$ ) High State $\left(\mathrm{V}_{\mathrm{OC}}=\mathrm{V}_{\text {ref }}\right)$ | $\begin{aligned} & \text { lock } \\ & \text { IOCH } \end{aligned}$ | - | $\begin{aligned} & 10 \\ & 0.2 \end{aligned}$ | $3.5$ | $\begin{aligned} & \mu \mathrm{A} \\ & \mathrm{~mA} \end{aligned}$ |
| Output Voltage Rise Time <br> Common-Emitter (See Figure 12) <br> Emitter-Follower (See Figure 13) | $\mathrm{tr}_{r}$ | - | $\begin{aligned} & 100 \\ & 100 \end{aligned}$ | $\begin{aligned} & 200 \\ & 200 \end{aligned}$ | ns |
| Output Voltage Fall Time <br> Common-Emitter (See Figure 12) <br> Emitter-Follower (See Figure 13) | $t_{f}$ | - | $\begin{aligned} & 25 \\ & 40 \end{aligned}$ | $\begin{aligned} & 100 \\ & 100 \end{aligned}$ | ns |

NOTE: 2. Low duty cycle pulse techniques are used during test to maintain junction temperature as close to ambient temperature as possible.

## TL494

ELECTRICAL CHARACTERISTICS ( $\mathrm{V}_{\mathrm{CC}}=15 \mathrm{~V}, \mathrm{C}_{\mathrm{T}}=0.01 \mu \mathrm{~F}, \mathrm{R}_{\mathrm{T}}=12 \mathrm{k} \Omega$, unless otherwise noted.)
For typical values $\mathrm{T}_{\mathrm{A}}=25^{\circ} \mathrm{C}$, for min/max values $\mathrm{T}_{\mathrm{A}}$ is the operating ambient temperature range that applies, unless otherwise noted.

| Characteristics | Symbol | Min | Typ | Max | Unit |
| :--- | :--- | :--- | :--- | :--- | :--- |

## ERROR AMPLIFIER SECTION

| Input Offset Voltage ( $\mathrm{V}_{\mathrm{O}}($ Pin 3$\left.)=2.5 \mathrm{~V}\right)$ | $\mathrm{V}_{\mathrm{IO}}$ | - | 2.0 | 10 | mV |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Input Offset Current ( $\left.\mathrm{V}_{\mathrm{O}}(\mathrm{Pin} 3)=2.5 \mathrm{~V}\right)$ | 10 | - | 5.0 | 250 | nA |
| Input Bias Current ( $\left.\mathrm{V}_{\mathrm{O}}(\mathrm{Pin} 3)=2.5 \mathrm{~V}\right)$ | IB | - | -0.1 | -1.0 | $\mu \mathrm{A}$ |
| Input Common Mode Voltage Range ( $\mathrm{VCC}=40 \mathrm{~V}, \mathrm{~T}_{\mathrm{A}}=25^{\circ} \mathrm{C}$ ) | VICR | -0.3 to $\mathrm{VCC}^{-2.0}$ |  |  | V |
| Open Loop Voltage Gain ( $\Delta \mathrm{V}_{\mathrm{O}}=3.0 \mathrm{~V}, \mathrm{~V}_{\mathrm{O}}=0.5 \mathrm{~V}$ to $\left.3.5 \mathrm{~V}, \mathrm{R}_{\mathrm{L}}=2.0 \mathrm{k} \Omega\right)$ | AVOL | 70 | 95 | - | dB |
| Unity-Gain Crossover Frequency ( $\mathrm{V}_{\mathrm{O}}=0.5 \mathrm{~V}$ to $3.5 \mathrm{~V}, \mathrm{R}_{\mathrm{L}}=2.0 \mathrm{k} \Omega$ ) | ${ }^{\mathrm{f}} \mathrm{C}$ - | - | 350 | - | kHz |
| Phase Margin at Unity-Gain ( $\mathrm{V}_{\mathrm{O}}=0.5 \mathrm{~V}$ to $3.5 \mathrm{~V}, \mathrm{R}_{\mathrm{L}}=2.0 \mathrm{k} \Omega$ ) | ¢m | - | 65 | - | deg. |
| Common Mode Rejection Ratio ( $\mathrm{V}_{\mathrm{CC}}=40 \mathrm{~V}$ ) | CMRR | 65 | 90 | - | dB |
| Power Supply Rejection Ratio ( $\left.\Delta \mathrm{V}_{\mathrm{CC}}=33 \mathrm{~V}, \mathrm{~V}_{\mathrm{O}}=2.5 \mathrm{~V}, \mathrm{R}_{\mathrm{L}}=2.0 \mathrm{k} \Omega\right)$ | PSRR | - | 100 | - | dB |
| Output Sink Current ( $\mathrm{V}_{\mathrm{O}}($ Pin 3) $=0.7 \mathrm{~V}$ ) | $\mathrm{l}^{\circ}$ | 0.3 | 0.7 | - | mA |
| Output Source Current ( $\mathrm{V}_{\mathrm{O}}($ Pin 3$\left.)=3.5 \mathrm{~V}\right)$ | ${ }^{1}+$ | 2.0 | -4.0 | - | mA |

PWM COMPARATOR SECTION (Test Circuit Figure 11)

| Input Threshold Voltage (Zero Duty Cycle) | $\mathrm{V}_{\mathrm{TH}}$ | - | 2.5 | 4.5 |
| :--- | :---: | :---: | :---: | :---: |
| Input Sink Current $(\mathrm{V}($ Pin 3$)=0.7 \mathrm{~V})$ | $\mathrm{I}_{-}$ | 0.3 | 0.7 | - |

DEADTIME CONTROL SECTION (Test Circuit Figure 11)

| Input Bias Current (Pin 4) (VPin $4=0 \mathrm{~V}$ to 5.25 V ) | IIB (DT) | - | -2.0 | -10 | $\mu \mathrm{A}$ |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Maximum Duty Cycle, Each Output, Push-Pull Mode <br> $\left(\mathrm{V}_{\text {Pin } 4}=0 \mathrm{~V}, \mathrm{C}_{\mathrm{T}}=0.01 \mu \mathrm{~F}, \mathrm{R}_{\mathrm{T}}=12 \mathrm{k} \Omega\right.$ ) <br> $\left(\mathrm{V}_{\text {Pin } 4}=0 \mathrm{~V}, \mathrm{C}_{\mathrm{T}}=0.001 \mu \mathrm{~F}, \mathrm{R}_{\mathrm{T}}=30 \mathrm{k} \Omega\right)$ | DC max | 45 | $\begin{aligned} & 48 \\ & 45 \end{aligned}$ | $\begin{aligned} & 50 \\ & 50 \end{aligned}$ | \% |
| Input Threshold Voltage (Pin 4) <br> (Zero Duty Cycle) <br> (Maximum Duty Cycle) | $\mathrm{V}_{\text {th }}$ | - | 2.8 | 3.3 | V |

## OSCILLATOR SECTION

| Frequency ( $\left.\mathrm{C}_{\mathrm{T}}=0.001 \mu \mathrm{~F}, \mathrm{R}_{\mathrm{T}}=30 \mathrm{k} \Omega\right)$ | $\mathrm{f}_{\mathrm{OSC}}$ | - | 40 | - | kHz |
| :--- | :---: | :---: | :---: | :---: | :---: |
| Standard Deviation of Frequency* $\left(\mathrm{C}_{\mathrm{T}}=0.001 \mu \mathrm{~F}, \mathrm{RT}=30 \mathrm{k} \Omega\right)$ | $\sigma \mathrm{osc}$ | - | 3.0 | - | $\%$ |
| Frequency Change with Voltage $\left(\mathrm{V}_{\mathrm{CC}}=7.0 \mathrm{~V}\right.$ to $\left.40 \mathrm{~V}, \mathrm{~T}_{\mathrm{A}}=25^{\circ} \mathrm{C}\right)$ | $\Delta \mathrm{f}_{\mathrm{Osc}}(\Delta \mathrm{V})$ | - | 0.1 | - | $\%$ |
| Frequency Change with Temperature $\left(\Delta \mathrm{T}_{\mathrm{A}}=\mathrm{T}_{\text {low }}\right.$ to $\left.\mathrm{T}_{\text {high }}\right)$ <br> $\left(\mathrm{C}_{\mathrm{T}}=0.01 \mu \mathrm{~F}, \mathrm{R}_{\mathrm{T}}=12 \mathrm{k} \Omega\right)$ | $\Delta \mathrm{f}_{\mathrm{Osc}}(\Delta \mathrm{T})$ | - | - | 12 | $\%$ |

UNDERVOLTAGE LOCKOUT SECTION

| Turn-On Threshold ( $\mathrm{V}_{\text {CC }}$ increasing, $\left.\mathrm{I}_{\text {ref }}=1.0 \mathrm{~mA}\right)$ | $\mathrm{V}_{\text {th }}$ | 5.5 | 6.43 | 7.0 | V |
| :--- | :--- | :--- | :--- | :--- | :--- |

## TOTAL DEVICE

| Standby Supply Current (Pin 6 at $\mathrm{V}_{\text {ref }}$, All other inputs and outputs open) $\begin{aligned} & \left(\mathrm{V}_{\mathrm{CC}}=15 \mathrm{~V}\right) \\ & \left(\mathrm{V}_{\mathrm{CC}}=40 \mathrm{~V}\right) \end{aligned}$ | ${ }^{\text {ICC }}$ | - | 5.5 7.0 | 10 15 | mA |
| :---: | :---: | :---: | :---: | :---: | :---: |
| $\begin{aligned} & \text { Average Supply Current } \\ & \quad\left(\mathrm{CT}_{\mathrm{T}}=0.01 \mu \mathrm{~F}, \mathrm{RT}_{\mathrm{T}}=12 \mathrm{k} \Omega, \mathrm{~V}_{(\text {Pin } 4)}=2.0 \mathrm{~V}\right) \\ & \left(\mathrm{V}_{\mathrm{CC}}=15 \mathrm{~V}\right)(\text { See Figure 12) } \end{aligned}$ |  | - | 7.0 | - | mA |

* Standard deviation is a measure of the statistical distribution about the mean as derived from the formula, $\sigma \sqrt{\begin{array}{l}N\left(X_{n}-\bar{X}\right)^{2} \\ n=1\end{array}}$

Figure 1. Representative Block Diagram


This device contains 46 active transistors.

Figure 2. Timing Diagram


## APPLICATIONS INFORMATION

## Description

The TL494 is a fixed-frequency pulse width modulation control circuit, incorporating the primary building blocks required for the control of a switching power supply. (See Figure 1.) An internal-linear sawtooth oscillator is frequencyprogrammable by two external components, $\mathrm{R}_{\top}$ and $\mathrm{C}_{\top}$. The approximate oscillator frequency is determined by:

$$
\mathrm{f}_{\mathrm{OSC}} \approx \frac{1.1}{\mathrm{R}_{\mathrm{T}} \cdot \mathrm{C}_{\mathrm{T}}}
$$

For more information refer to Figure 3.
Output pulse width modulation is accomplished by comparison of the positive sawtooth waveform across capacitor $\mathrm{C} \boldsymbol{j}$ to either of two control signals. The NOR gates, which drive output transistors Q1 and Q2, are enabled only when the flip-flop clock-input line is in its low state. This happens only during that portion of time when the sawtooth voltage is greater than the control signals. Therefore, an increase in control-signal amplitude causes a corresponding linear decrease of output pulse width. (Refer to the Timing Diagram shown in Figure 2.)

The control signals are external inputs that can be fed into the deadtime control, the error amplifier inputs, or the feedback input. The deadtime control comparator has an effective 120 mV input offset which limits the minimum output deadtime to approximately the first $4 \%$ of the sawtooth-cycle time. This would result in a maximum duty cycle on a given output of $96 \%$ with the output control grounded, and $48 \%$ with it connected to the reference line. Additional deadtime may be imposed on the output by setting the deadtime-control input to a fixed voltage, ranging between 0 V to 3.3 V .

## Functional Table

| Input/Output <br> Controls | Output Function | $\frac{\mathbf{f}_{\text {out }}}{\mathbf{f}_{\mathbf{O S C}}}=$ |
| :---: | :--- | :---: |
| Grounded | Single-ended PWM @ Q1 and Q2 | 1.0 |
| $@ \mathrm{~V}_{\text {ref }}$ | Push-pull Operation | 0.5 |

The pulse width modulator comparator provides a means for the error amplifiers to adjust the output pulse width from the maximum percent on-time, established by the deadtime control input, down to zero, as the voltage at the feedback pin varies from 0.5 V to 3.5 V . Both error amplifiers have a common mode input range from -0.3 V to $\left(\mathrm{V}_{\mathrm{CC}}-2 \mathrm{~V}\right)$, and
may be used to sense power-supply output voltage and current. The error-amplifier outputs are active high and are ORed together at the noninverting input of the pulse-width modulator comparator. With this configuration, the amplifier that demands minimum output on time, dominates control of the loop.

When capacitor $\mathrm{C}_{\boldsymbol{T}}$ is discharged, a positive pulse is generated on the output of the deadtime comparator, which clocks the pulse-steering flip-flop and inhibits the output transistors, Q1 and Q2. With the output-control connected to the reference line, the pulse-steering flip-flop directs the modulated pulses to each of the two output transistors alternately for push-pull operation. The output frequency is equal to half that of the oscillator. Output drive can also be taken from Q1 or Q2, when single-ended operation with a maximum on-time of less than $50 \%$ is required. This is desirable when the output transformer has a ringback winding with a catch diode used for snubbing. When higher output-drive currents are required for single-ended operation, Q1 and Q2 may be connected in parallel, and the output-mode pin must be tied to ground to disable the flip-flop. The output frequency will now be equal to that of the oscillator.

The TL494 has an internal 5.0 V reference capable of sourcing up to 10 mA of load current for external bias circuits. The reference has an internal accuracy of $\pm 5.0 \%$ with a typical thermal drift of less than 50 mV over an operating temperature range of $0^{\circ}$ to $70^{\circ} \mathrm{C}$.

Figure 3. Oscillator Frequency versus Timing Resistance


Figure 4. Open Loop Voltage Gain and Phase versus Frequency


Figure 6. Percent Duty Cycle versus
Deadtime Control Voltage


Figure 8. Common-Emitter Configuration Output Saturation Voltage versus Collector Current


Figure 5. Percent Deadtime versus Oscillator Frequency


Figure 7. Emitter-Follower Configuration Output Saturation Voltage versus Emitter Current


Figure 9. Standby Supply Current versus Supply Voltage


Figure 10. Error-Amplifier Characteristics


Figure 12. Common-Emitter Configuration Test Circuit and Waveform


Figure 11. Deadtime and Feedback Control Circuit


Figure 13. Emitter-Follower Configuration Test Circuit and Waveform


Figure 14. Error-Amplifier Sensing Techniques


Figure 15. Deadtime Control Circuit


Max. \% on Time, each output $\approx 45-\left(\frac{80}{1+\frac{\mathrm{R} 1}{\mathrm{R} 2}}\right)$


Figure 16. Soft-Start Circuit


Figure 17. Output Connections for Single-Ended and Push-Pull Configurations


Figure 18. Slaving Two or More Control Circuits


Figure 19. Operation with $\mathrm{V}_{\text {in }}>40 \mathrm{~V}$ Using External Zener


Figure 20. Pulse Width Modulated Push-Pull Converter


| Test | Conditions | Results |
| :--- | :--- | :--- |
| Line Regulation | $\mathrm{V}_{\mathrm{in}}=10 \mathrm{~V}$ to 40 V | $14 \mathrm{mV} 0.28 \%$ |
| Load Regulation | $\mathrm{V}_{\mathrm{in}}=28 \mathrm{~V}, \mathrm{I} \mathrm{O}=1.0 \mathrm{~mA}$ to 1.0 A | $3.0 \mathrm{mV} 0.06 \%$ |
| Output Ripple | $\mathrm{V}_{\mathrm{in}}=28 \mathrm{~V}, \mathrm{I} \mathrm{O}=1.0 \mathrm{~A}$ | 65 mV pp P.A.R.D. |
| Short Circuit Current | $\mathrm{V}_{\mathrm{in}}=28 \mathrm{~V}, \mathrm{R}_{\mathrm{L}}=0.1 \Omega$ | 1.6 A |
| Efficiency | $\mathrm{V}_{\mathrm{in}}=28 \mathrm{~V}, \mathrm{I}=1.0 \mathrm{~A}$ | $71 \%$ |

$\mathrm{L} 1-3.5 \mathrm{mH} @ 0.3 \mathrm{~A}$
T1 - Primary: 20T C.T. \#28 AWG Secondary: 120T C.T. \#36 AWG Core: Ferroxcube 1408P-L00-3CB

Figure 21. Pulse Width Modulated Step-Down Converter


| Test | Conditions | Results |
| :--- | :--- | :---: |
| Line Regulation | $\mathrm{V}_{\text {in }}=8.0 \mathrm{~V}$ to 40 V | $3.0 \mathrm{mV} \quad 0.01 \%$ |
| Load Regulation | $\mathrm{V}_{\text {in }}=12.6 \mathrm{~V}, \mathrm{I} \mathrm{O}=0.2 \mathrm{~mA}$ to 200 mA | $5.0 \mathrm{mV} \quad 0.02 \%$ |
| Output Ripple | $\mathrm{V}_{\text {in }}=12.6 \mathrm{~V}, \mathrm{I} \mathrm{O}=200 \mathrm{~mA}$ | $40 \mathrm{mV} \mathrm{pp} \quad$ P.A.R.D. |
| Short Circuit Current | $\mathrm{V}_{\text {in }}=12.6 \mathrm{~V}, \mathrm{R}_{\mathrm{L}}=0.1 \Omega$ | 250 mA |
| Efficiency | $\mathrm{V}_{\mathrm{in}}=12.6 \mathrm{~V}, \mathrm{IO}=200 \mathrm{~mA}$ | $72 \%$ |

## OUTLINE DIMENSIONS



Motorola reserves the right to make changes without further notice to any products herein. Motorola makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does Motorola assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation consequential or incidental damages. "Typical" parameters which may be provided in Motorola data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. Motorola does not convey any license under its patent rights nor the rights of others. Motorola products are not designed, intended, or authorized for use as components in systems intended for surgical implant into the body, or other applications intended to support or sustain life, or for any other application in which the failure of the Motorola product could create a situation where personal injury or death may occur. Should Buyer purchase or use Motorola products for any such unintended or unauthorized application, Buyer shall indemnify and hold Motorola and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that Motorola was negligent regarding the design or manufacture of the part. Motorola and (M) registered trademarks of Motorola, Inc. Motorola, Inc. is an Equal Opportunity/Affirmative Action Employer.

## How to reach us:

USA/EUROPE/Locations Not Listed: Motorola Literature Distribution; P.O. Box 20912; Phoenix, Arizona 85036. 1-800-441-2447 or 602-303-5454

MFAX: RMFAX0@email.sps.mot.com - TOUCHTONE 602-244-6609
INTERNET: http://Design-NET.com

JAPAN: Nippon Motorola Ltd.; Tatsumi-SPD-JLDC, 6F Seibu-Butsuryu-Center, 3-14-2 Tatsumi Koto-Ku, Tokyo 135, Japan. 03-81-3521-8315

ASIA/PACIFIC: Motorola Semiconductors H.K. Ltd.; 8B Tai Ping Industrial Park, 51 Ting Kok Road, Tai Po, N.T., Hong Kong. 852-26629298

