

TL494 Pulse-Width-Modulation Control Circuits

FEATURES

- Complete PWM Power-Control Circuitry
- Uncommitted Outputs for 200-mA Sink or Source Current
- Output Control Selects Single-Ended or Push-Pull Operation
- Internal Circuitry Prohibits Double Pulse at Either Output
- Variable Dead Time Provides Control Over Total Range
- Internal Regulator Provides a Stable 5-V Reference Supply With 5% Tolerance
- Circuit Architecture Allows Easy Synchronization

DESCRIPTION

The TL494 device incorporates all the functions required in the construction of a pulse-width-modulation (PWM) control circuit on a single chip. Designed primarily for power-supply control, this device offers the flexibility to tailor the power-supply control circuitry to a specific application.

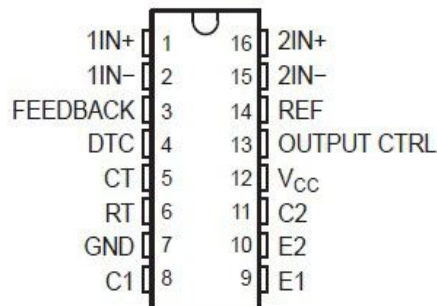
The TL494 device contains two error amplifiers, an on-chip adjustable oscillator, a dead-time control (DTC) comparator, a pulse-steering control flip-flop, a 5-V, 5%-precision regulator, and output-control circuits.

The error amplifiers exhibit a common-mode voltage range from -0.3 V to $V_{CC} - 2\text{ V}$. The dead-time control comparator has a fixed offset that provides approximately 5% dead time. The on-chip oscillator can be bypassed by terminating RT to the reference output and providing a sawtooth input to CT, or it can drive the common circuits in synchronous multiple-rail power supplies.

The uncommitted output transistors provide either common-emitter or emitter-follower output capability. The TL494 device provides for push-pull or single-ended output operation, which can be selected through the output-control function. The architecture of this device prohibits the possibility of either output being pulsed twice during push-pull operation.

The TL494C device is characterized for operation from 0°C to 70°C . The TL494I device is characterized for operation from -40°C to 85°C .

D, DB, N, NS, OR PW PACKAGE
(TOP VIEW)



Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)⁽¹⁾

		MIN	MAX	UNIT
V _{CC}	Supply voltage ⁽²⁾		41	V
V _I	Amplifier input voltage		V _{CC} + 0.3	V
V _O	Collector output voltage		41	V
I _O	Collector output current		250	mA
θ _{JA}	Package thermal impedance ⁽³⁾⁽⁴⁾	D package	73	°C/W
		DB package	82	
		N package	67	
		NS package	64	
		PW package	108	
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds			260	°C
T _{stg}	Storage temperature range	-65	150	°C

- (1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) All voltages are with respect to the network ground terminal.
- (3) Maximum power dissipation is a function of T_J(max), θ_{JA}, and T_A. The maximum allowable power dissipation at any allowable ambient temperature is P_D = (T_J(max) - T_A)/θ_{JA}. Operating at the absolute maximum T_J of 150°C can affect reliability.
- (4) The package thermal impedance is calculated in accordance with JESD 51-7.

Recommended Operating Conditions

		MIN	MAX	UNIT	
V _{CC}	Supply voltage	7	40	V	
V _I	Amplifier input voltage	-0.3	V _{CC} - 2	V	
V _O	Collector output voltage		40	V	
	Collector output current (each transistor)		200	mA	
	Current into feedback terminal		0.3	mA	
f _{OSC}	Oscillator frequency	1	300	kHz	
C _T	Timing capacitor	0.47	10000	nF	
R _T	Timing resistor	1.8	500	kΩ	
T _A	Operating free-air temperature	TL494C	0	70	°C
		TL494I	-40	85	

Electrical Characteristics

over recommended operating free-air temperature range, $V_{CC} = 15\text{ V}$, $f = 10\text{ kHz}$ (unless otherwise noted)

Reference Section

PARAMETER	TEST CONDITIONS ⁽¹⁾	TL494C, TL494I			UNIT
		MIN	TYP ⁽²⁾	MAX	
Output voltage (REF)	$I_O = 1\text{ mA}$	4.75	5	5.25	V
Input regulation	$V_{CC} = 7\text{ V to } 40\text{ V}$		2	25	mV
Output regulation	$I_O = 1\text{ mA to } 10\text{ mA}$		1	15	mV
Output voltage change with temperature	$\Delta T_A = \text{MIN to MAX}$		2	10	mV/V
Short-circuit output current ⁽³⁾	REF = 0 V		25		mA

(1) For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions.

(2) All typical values, except for parameter changes with temperature, are at $T_A = 25^\circ\text{C}$.

(3) Duration of short circuit should not exceed one second.

Oscillator Section

$C_T = 0.01\text{ }\mu\text{F}$, $R_T = 12\text{ k}\Omega$ (see Figure 1)

PARAMETER	TEST CONDITIONS ⁽¹⁾	TL494C, TL494I			UNIT
		MIN	TYP ⁽²⁾	MAX	
Frequency			10		kHz
Standard deviation of frequency ⁽³⁾	All values of V_{CC} , C_T , R_T , and T_A constant		100		Hz/kHz
Frequency change with voltage	$V_{CC} = 7\text{ V to } 40\text{ V}$, $T_A = 25^\circ\text{C}$		1		Hz/kHz
Frequency change with temperature ⁽⁴⁾	$\Delta T_A = \text{MIN to MAX}$			10	Hz/kHz

(1) For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions.

(2) All typical values, except for parameter changes with temperature, are at $T_A = 25^\circ\text{C}$.

(3) Standard deviation is a measure of the statistical distribution about the mean as derived from the formula:

$$\sigma = \sqrt{\frac{\sum_{n=1}^N (x_n - \bar{X})^2}{N - 1}}$$

(4) Temperature coefficient of timing capacitor and timing resistor are not taken into account.

Error-Amplifier Section

See Figure 2

PARAMETER	TEST CONDITIONS	TL494C, TL494I			UNIT
		MIN	TYP ⁽¹⁾	MAX	
Input offset voltage	$V_O (\text{FEEDBACK}) = 2.5\text{ V}$		2	10	mV
Input offset current	$V_O (\text{FEEDBACK}) = 2.5\text{ V}$		25	250	nA
Input bias current	$V_O (\text{FEEDBACK}) = 2.5\text{ V}$		0.2	1	μA
Common-mode input voltage range	$V_{CC} = 7\text{ V to } 40\text{ V}$	-0.3 to $V_{CC} - 2$			V
Open-loop voltage amplification	$\Delta V_O = 3\text{ V}$, $V_O = 0.5\text{ V to } 3.5\text{ V}$, $R_L = 2\text{ k}\Omega$		70	95	dB
Unity-gain bandwidth	$V_O = 0.5\text{ V to } 3.5\text{ V}$, $R_L = 2\text{ k}\Omega$		800		kHz
Common-mode rejection ratio	$\Delta V_O = 40\text{ V}$, $T_A = 25^\circ\text{C}$		65	80	dB
Output sink current (FEEDBACK)	$V_{ID} = -15\text{ mV to } -5\text{ V}$, $V (\text{FEEDBACK}) = 0.7\text{ V}$		0.3	0.7	mA
Output source current (FEEDBACK)	$V_{ID} = 15\text{ mV to } 5\text{ V}$, $V (\text{FEEDBACK}) = 3.5\text{ V}$		-2		mA

(1) All typical values, except for parameter changes with temperature, are at $T_A = 25^\circ\text{C}$.

Electrical Characteristics

over recommended operating free-air temperature range, $V_{CC} = 15\text{ V}$, $f = 10\text{ kHz}$ (unless otherwise noted)

Output Section

PARAMETER		TEST CONDITIONS	MIN	TYP ⁽¹⁾	MAX	UNIT
Collector off-state current		$V_{CE} = 40\text{ V}$, $V_{CC} = 40\text{ V}$		2	100	μA
Emitter off-state current		$V_{CC} = V_C = 40\text{ V}$, $V_E = 0$			-100	μA
Collector-emitter saturation voltage	Common emitter	$V_E = 0$, $I_C = 200\text{ mA}$		1.1	1.3	V
	Emitter follower	$V_{O(C1\text{ or }C2)} = 15\text{ V}$, $I_E = -200\text{ mA}$		1.5	2.5	
Output control input current		$V_I = V_{ref}$			3.5	mA

(1) All typical values, except for temperature coefficient, are at $T_A = 25^\circ\text{C}$.

Dead-Time Control Section

See [Figure 1](#)

PARAMETER		TEST CONDITIONS	MIN	TYP ⁽¹⁾	MAX	UNIT
Input bias current (DEAD-TIME CTRL)		$V_I = 0$ to 5.25 V		-2	-10	μA
Maximum duty cycle, each output		V_I (DEAD-TIME CTRL) = 0 , $C_T = 0.01\ \mu\text{F}$, $R_T = 12\ \text{k}\Omega$		45		%
Input threshold voltage (DEAD-TIME CTRL)	Zero duty cycle			3	3.3	V
	Maximum duty cycle		0			

(1) All typical values, except for temperature coefficient, are at $T_A = 25^\circ\text{C}$.

PWM Comparator Section

See [Figure 1](#)

PARAMETER		TEST CONDITIONS	MIN	TYP ⁽¹⁾	MAX	UNIT
Input threshold voltage (FEEDBACK)		Zero duty cycle		4	4.5	V
Input sink current (FEEDBACK)		V (FEEDBACK) = 0.7 V	0.3	0.7		mA

(1) All typical values, except for temperature coefficient, are at $T_A = 25^\circ\text{C}$.

Total Device

PARAMETER		TEST CONDITIONS	MIN	TYP ⁽¹⁾	MAX	UNIT
Standby supply current	$R_T = V_{ref}$, All other inputs and outputs open	$V_{CC} = 15\text{ V}$		6	10	mA
		$V_{CC} = 40\text{ V}$		9	15	
Average supply current		V_I (DEAD-TIME CTRL) = 2 V , See Figure 1		7.5		mA

(1) All typical values, except for temperature coefficient, are at $T_A = 25^\circ\text{C}$.

Switching Characteristics

$T_A = 25^\circ\text{C}$

PARAMETER		TEST CONDITIONS	MIN	TYP ⁽¹⁾	MAX	UNIT
Rise time	Common-emitter configuration, See Figure 3			100	200	ns
Fall time				25	100	ns
Rise time	Emitter-follower configuration, See Figure 4			100	200	ns
Fall time				40	100	ns

(1) All typical values, except for temperature coefficient, are at $T_A = 25^\circ\text{C}$.