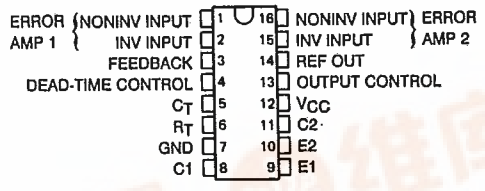


TL594I, TL594C, TL595C PULSE-WIDTH-MODULATION CONTROL CIRCUITS

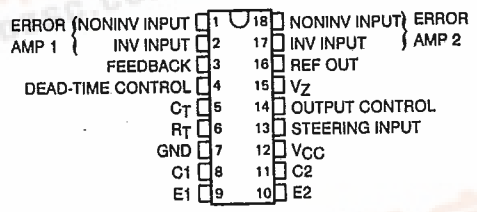
D2712, APRIL 1983—REVISED OCTOBER 1988

- 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 Trimmed to 1%
- Circuit Architecture allows Easy Synchronization
- Under-Voltage Lockout for Low VCC Conditions
- TL595 has On-Chip 39-V Zener and External Control of Output Steering

TL594I, TL594C . . . D, J, OR N PACKAGE
(TOP VIEW)



TL595C . . . N
DUAL-IN-LINE PACKAGE
(TOP VIEW)



2
Data Sheets

description

The TL594 and TL595 devices each incorporates on a single monolithic chip all the functions required in the construction of a pulse-width-modulation control circuit. Designed primarily for power supply control, these devices offer the systems engineer the flexibility to tailor the power supply control circuitry to his application.

The TL594 contains two error amplifiers, an on-chip adjustable oscillator, a dead-time control comparator, pulse-steering control flip-flop, 5-V regulator with a precision of 1%, an under-voltage lockout control circuit, and output control circuitry.

The error amplifiers exhibit a common-mode voltage range from -0.3V to VCC -2V. The dead-time control comparator has a fixed offset that provides approximately 5% dead time when externally altered. The on-chip oscillator may be bypassed by terminating RT (pin 6) to the reference output and providing a sawtooth input to CT (pin 5), or it may be used to drive the common circuitry in synchronous multiple-rail power supplies.

The uncommitted output transistors provide either common-emitter or emitter-follower output capability. Each device provides for push-pull or single-ended output operation with selection by

FUNCTION TABLE

INPUTS		OUTPUT FUNCTION
OUTPUT CONTROL	STEERING INPUT (TL595 ONLY)	
$V_I \leq 0$	Open	Single-ended or parallel output
$V_I \geq V_{ref}$	Open	Normal push-pull operation
$V_I \geq V_{ref}$	$V_I < 0$	PWM Output at Q1
$V_I \geq V_{ref}$	$V_I \geq V_{ref}$	PWM Output at Q2

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**TL594I, TL594C, TL595C
PULSE-WIDTH-MODULATION CONTROL CIRCUITS**

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description (continued)

means of the output-control function. The architecture of these devices prohibits the possibility of either output being pulsed twice during push-pull operation. The undervoltage lockout control circuit locks the outputs off until the internal circuitry is operational.

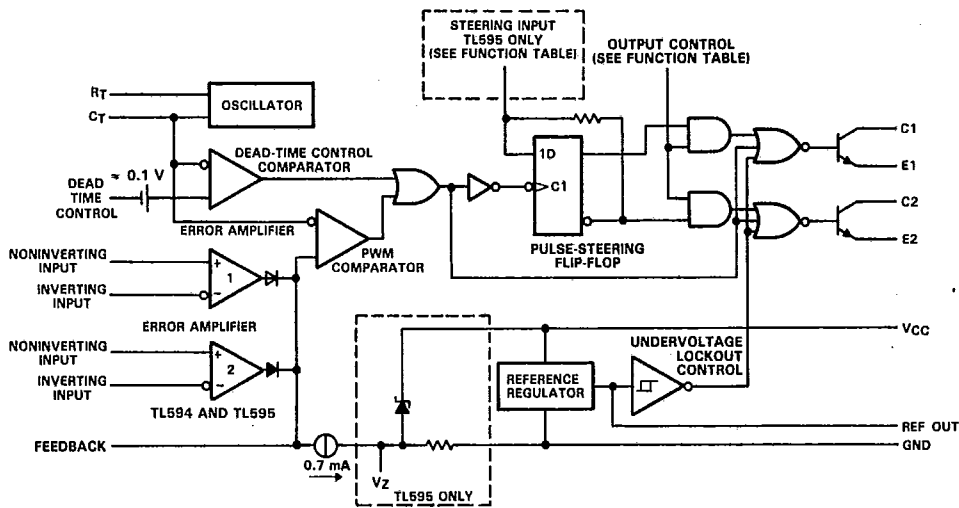
The TL595 provides the identical functions found in the TL594. In addition, the TL595 also contains an on-chip 39-V zener diode for high-voltage applications where V_{CC} is greater than 40 V, and an output steering control that overrides the internal control of the pulse-steering flip-flop.

The TL594I is characterized for operation from -25°C to 85°C . The TL594C and TL595C are characterized for operation from 0°C to 70°C .

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Data Sheets

functional block diagram



TL594I, TL594C, TL595C
PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

	TL594I	TL594C TL595C	UNIT
Supply voltage, V_{CC} (see Note 1)	41	41	V
Amplifier input voltages	$V_{CC}+0.3$	$V_{CC}+0.3$	V
Collector output voltage	41	41	V
Collector output current	250	250	mA
Continuous total dissipation	See Dissipation Rating Table		
Operating free-air temperature range	-25 to 85	0 to 70	°C
Storage temperature range	-65 to 150	-65 to 150	°C
Lead temperature 1,8 mm (1/16 inch) from case for 60 seconds: J package	300	300	°C
Lead temperature 1,8 mm (1/16 inch) from case for 10 seconds: D or N package	260	260	°C

NOTE 1: All voltage values, except differential voltages, are with respect to the network ground terminal.

DISSIPATION RATING TABLE

PACKAGE	$T_A \leq 25^\circ\text{C}$ POWER RATING	DERATING FACTOR	DERATE ABOVE T_A	$T_A = 70^\circ\text{C}$ POWER RATING	$T_A = 85^\circ\text{C}$ POWER RATING
D	950 mW	7.6 mW/°C	25°C	608 mW	494 mW
J	1000 mW	8.2 mW/°C	28°C	656 mW	533 mW
N	1000 mW	9.2 mW/°C	41°C	736 mW	598 mW

recommended operating conditions

	TL594I		TL594C TL595C		UNIT
	MIN	MAX	MIN	MAX	
Supply voltage, V_{CC}	7	40	7	40	V
Amplifier input voltages, V_i	-0.3	$V_{CC}-2$	-0.3	$V_{CC}-2$	V
Collector output voltage, V_O	40		40		V
Collector output current (each transistor)	200		200		mA
Current into feedback terminal	0.3		0.3		mA
Timing capacitor, C_T	0.47	10 000	0.47	10 000	nF
Timing resistor, R_T	1.8	500	1.8	500	k Ω
Oscillator frequency	1	300	1	300	kHz
Operating free-air temperature, T_A	-25	85	0	70	°C

Data Sheets 2

TL594I, TL594C, TL595C
PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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electrical characteristics over recommended operating free-air temperature range, VCC = 15 V (unless otherwise noted)

reference section

PARAMETER	TEST CONDITIONS†	MIN	TYP‡	MAX	UNIT
Output voltage (V _{ref})	I _O = 1 mA, T _A = 25°C	4.95	5	5.05	V
Input regulation	V _{CC} = 7 V to 40 V, T _A = 25°C		2	25	mV
Output regulation	I _O = 1 to 10 mA, T _A = 25°C		14	35	mV
Output voltage change with temperature	ΔT _A = MIN to MAX		0.2%	1%	
Short-circuit output current§	V _{ref} = 0	10	35	50	mA

oscillator section (see Figure 2)

PARAMETER	TEST CONDITIONS†	MIN	TYP‡	MAX	UNIT
Frequency			10		kHz
Standard deviation of frequency¶	All values of V _{CC} , C _T , R _T , T _A constant		10%		
Frequency change with voltage	V _{CC} = 7 V to 40 V, T _A = 25°C		0.1%		
Frequency change with temperature	ΔT _A = MIN to MAX			12%	

amplifier sections (see Figure 1)

PARAMETER	TEST CONDITIONS	MIN	TYP‡	MAX	UNIT
Input offset voltage, error amplifier	Feedback pin at 2.5 V		2	10	mV
Input offset current	Feedback control at 2.5 V		25	250	nA
Input bias current	Feedback control at 2.5 V		0.2	1	μA
Common-mode input voltage range, error amplifier	V _{CC} = 7 V to 40 V	-0.3 to V _{CC} -2			V
Open-loop voltage amplification, error amplifier	ΔV _O = 3 V, R _L = 2 kΩ, V _O = 0.5 V to 3.5 V	70	95		dB
Unity-gain bandwidth	V _O = 0.5 V to 3.5 V, R _L = 2 kΩ		800		kHz
Common-mode rejection ratio, error amplifier	V _{CC} = 40 V, T _A = 25°C	65	80		dB
Output sink current (pin 3)	V _{ID} = -15 mV to -5 V, Feedback control at 0.5 V	0.3	0.7		mA
Output source current (pin 3)	V _{ID} = 15 mV to 5 V, Feedback at 3.5 V	-2			mA

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

‡ All typical values except for parameter changes with temperature are at T_A = 25°C.

§ Duration of the short-circuit should not exceed one second.

¶ Standard deviation is a measure of the statistical distribution about the mean as derived from the formula

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

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Data Sheets

TL594I, TL594C, TL595C
PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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

dead-time control section (see Figure 2)

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PARAMETER	TEST CONDITIONS	MIN	TYP†	MAX	UNIT
Input bias current (pin 4)	$V_I = 0$ to 5.25 V		-2	-10	μA
Maximum duty cycle, each output	Dead-time control at 0 V	45%			
Input threshold voltage (pin 4)	Zero duty cycle		3	3.3	V
	Maximum duty cycle	0			

output section

PARAMETER		TEST CONDITIONS	MIN	TYP†	MAX	UNIT
Collector off-state current		$V_{CE} = 40\text{ V}$, $V_{CC} = 40\text{ V}$		2	100	μA
		$V_C = 15\text{ V}$, $V_E = 0\text{ V}$, $V_{CC} = 1$ to 3 V, Dead-time and output control pins at 0 V		4	200	
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	$V_C = 15\text{ V}$, $I_E = -200\text{ mA}$		1.5	2.5	
Output control input current		$V_I = V_{ref}$			3.5	mA

pwm comparator section (see Figure 2)

PARAMETER	TEST CONDITIONS	MIN	TYP†	MAX	UNIT
Input threshold voltage (pin 3)	Zero duty cycle		4	4.5	V
Input sink current (pin 3)	$V_{(pin\ 3)} = 0.5\text{ V}$	0.3	0.7		mA

under-voltage lockout section (see Figure 2)

PARAMETER	TEST CONDITION‡	MIN	MAX	UNIT
Threshold voltage	$T_A = 25^\circ\text{C}$		6	V
	$\Delta T_A = \text{MIN to MAX}$	3.5	6.9	
Hysteresis§		100		mV

total device (see Figure 2)

PARAMETER	TEST CONDITIONS	MIN	TYP†	MAX	UNIT
Standby supply current	Pin 6 at V_{ref} , All other inputs and outputs open		9	15	mA
		$V_{CC} = 15\text{ V}$			
		$V_{CC} = 40\text{ V}$	11	18	
Average supply current	Dead-time Control at 2 V, See Figure 2		12.4		mA

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

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

§ Hysteresis is the difference between the positive-going input threshold voltage and the negative-going input threshold voltage.

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Data Sheets

TL594I, TL594C, TL595C
PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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switching characteristics, $T_A = 25^\circ\text{C}$

PARAMETER	TEST CONDITIONS	MIN	TYP†	MAX	UNIT
Output voltage rise time	Common-emitter configuration,		100	200	ns
Output voltage fall time	See Figure 3		30	100	
Output voltage rise time	Emitter-follower configuration,		200	400	ns
Output voltage fall time	See Figure 4		45	100	

† All typical values are at $T_A = 25^\circ\text{C}$.

PARAMETER MEASUREMENT INFORMATION

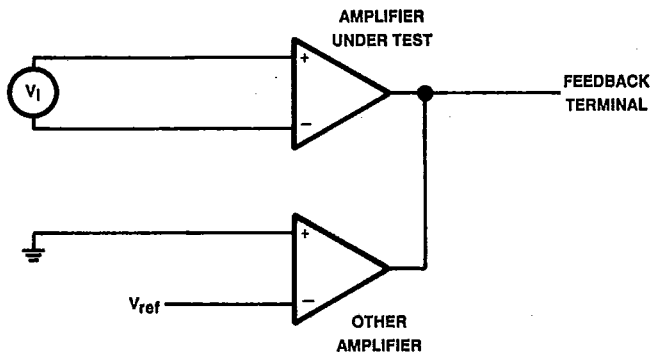


FIGURE 1. AMPLIFIER CHARACTERISTICS

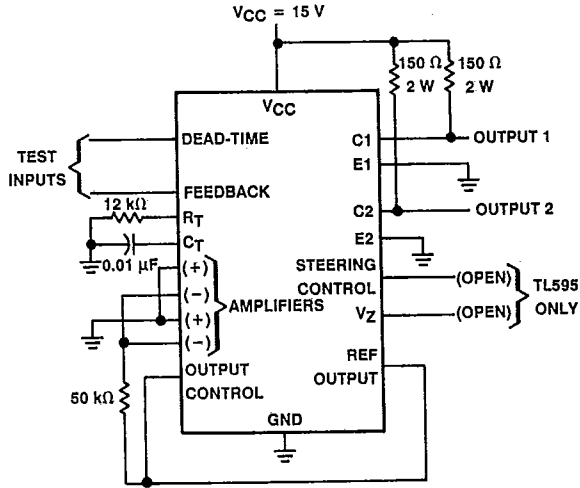
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Data Sheets

TL594I, TL594C, TL595C
PULSE-WIDTH-MODULATION CONTROL CIRCUITS

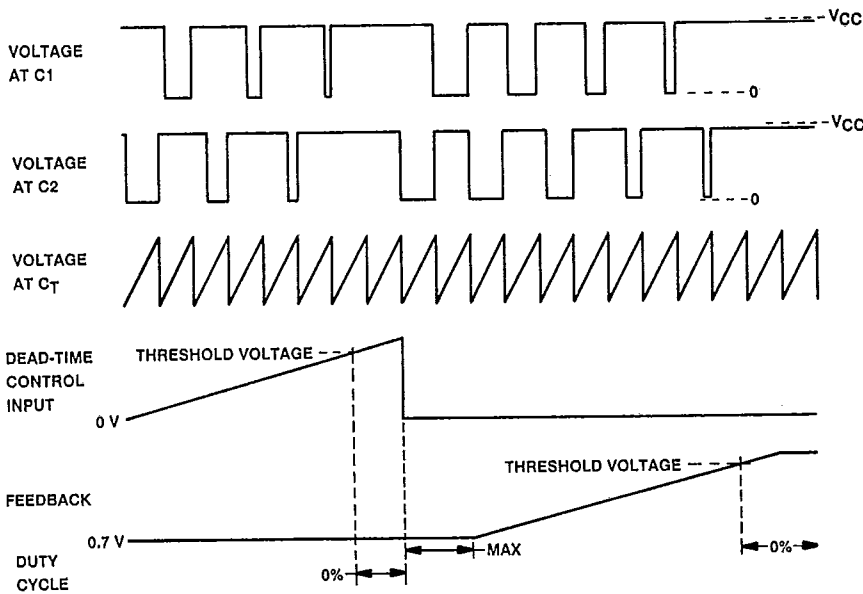
PARAMETER MEASUREMENT INFORMATION

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TEST CIRCUIT

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VOLTAGE WAVEFORMS

FIGURE 2. OPERATIONAL TEST CIRCUIT AND WAVEFORMS

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PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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PARAMETER MEASUREMENT INFORMATION

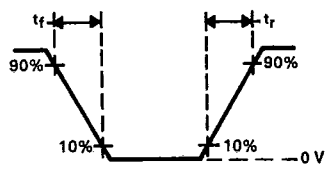
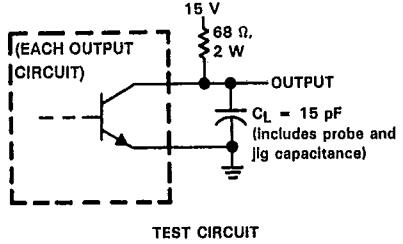


FIGURE 3. COMMON-EMITTER CONFIGURATION

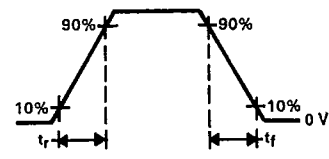
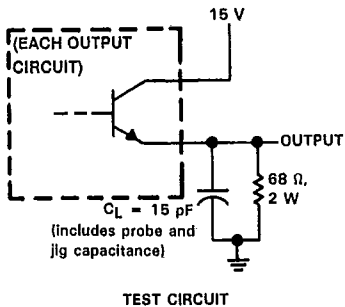


FIGURE 4. EMITTER-FOLLOWER CONFIGURATION

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PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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TYPICAL CHARACTERISTICS

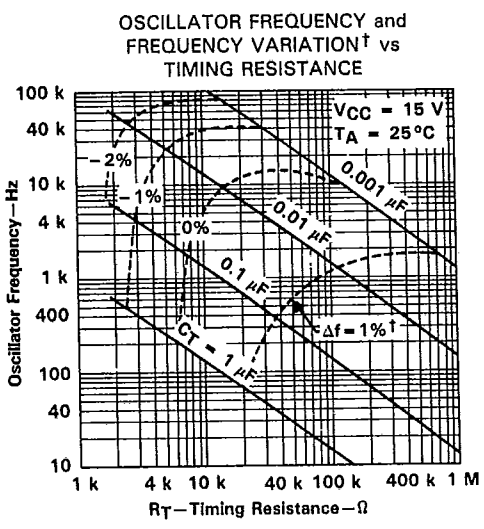


FIGURE 5

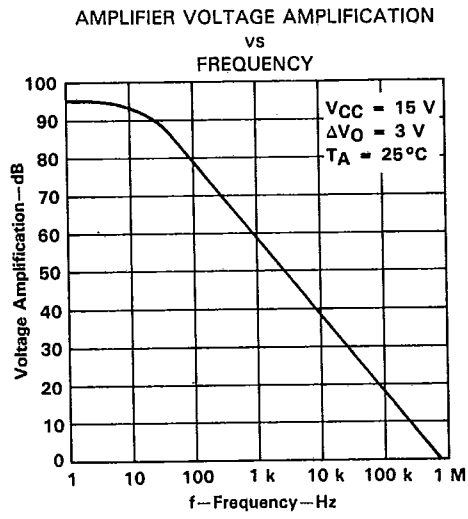


FIGURE 6

† Frequency variation (Δf) is the change in oscillator frequency that occurs over the full temperature range.

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Data Sheets