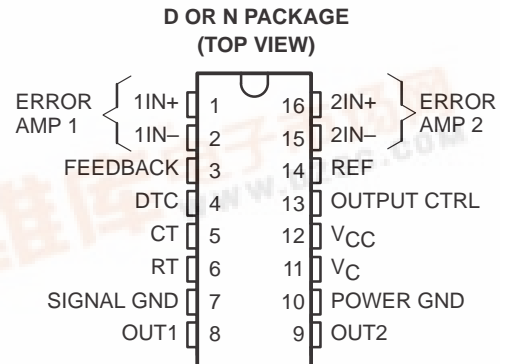


# PULSE-WIDTH-MODULATION CONTROL CIRCUITS

SLVS053C – FEBRUARY 1988 – REVISED JULY 1999

- Complete PWM Power Control Function
- Totem-Pole Outputs for 200-mA Sink or Source Current
- Output Control Selects Parallel 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% Tolerance
- On-Board Output Current-Limiting Protection
- Undervoltage Lockout for Low  $V_{CC}$  Conditions
- Separate Power and Signal Grounds
- TL598Q Has Extended Temperature Range . . .  $-40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$



## description

The TL598 incorporates all the functions required in the construction of pulse-width-modulated (PWM) controlled systems on a single chip. Designed primarily for power-supply control, the TL598 provides the systems engineer with the flexibility to tailor the power-supply control circuits to a specific application.

The TL598 contains two error amplifiers, an internal oscillator (externally adjustable), a dead-time control (DTC) comparator, a pulse-steering flip-flop, a 5-V precision reference, undervoltage lockout control, and output control circuits. Two totem-pole outputs provide exceptional rise- and fall-time performance for power FET control. The outputs share a common source supply and common power ground terminals, which allow system designers to eliminate errors caused by high current-induced voltage drops and common-mode noise.

The error amplifier has a common-mode voltage range from 0 V to  $V_{CC} - 2$  V. The DTC comparator has a fixed offset that prevents overlap of the outputs during push-pull operation. A synchronous multiple supply operation can be achieved by connecting RT to the reference output and providing a sawtooth input to CT.

The TL598 device provides an output control function to select either push-pull or parallel operation. Circuit architecture prevents either output from being pulsed twice during push-pull operation. The output frequency for push-pull applications is one-half the oscillator frequency ( $f_o = \frac{1}{2 RT CT}$ ). For single-ended applications:

$$f_o = \frac{1}{RT CT}$$

The TL598C is characterized for operation from  $0^{\circ}\text{C}$  to  $70^{\circ}\text{C}$ . The TL598Q is characterized for operation from  $-40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ .

Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.



# TL598 PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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FUNCTION TABLE

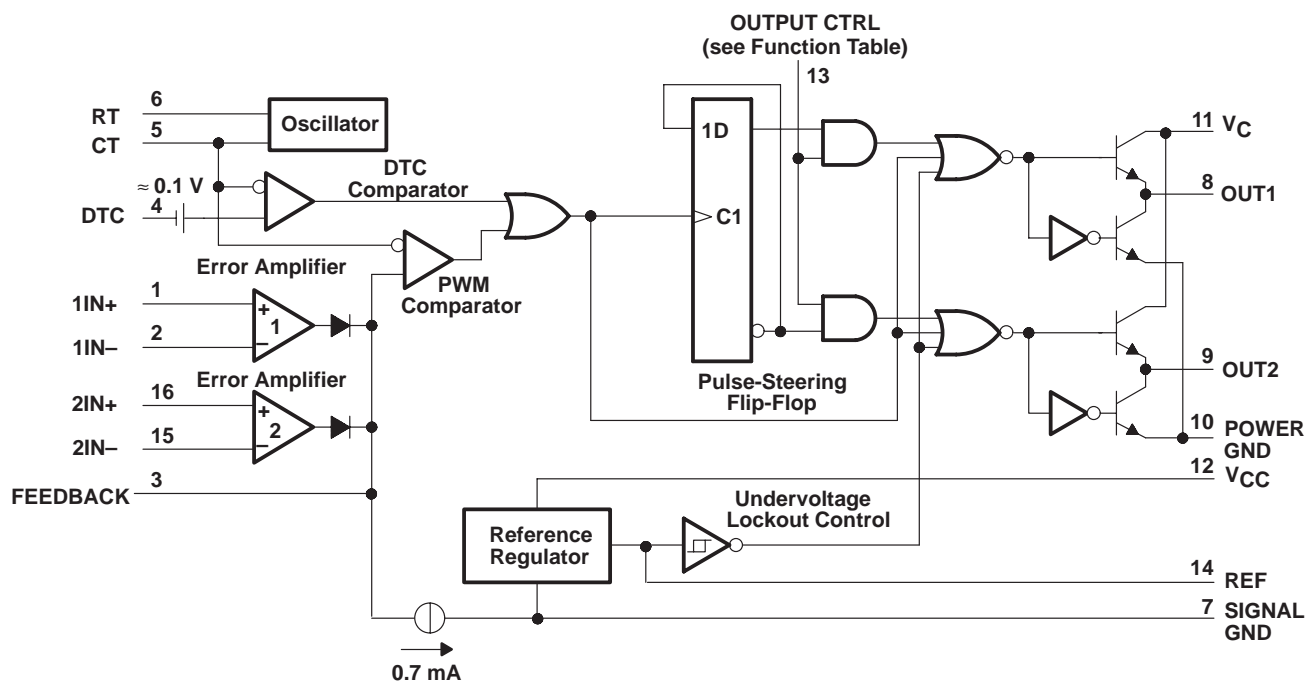
INPUT/OUTPUT CTRL	OUTPUT FUNCTION
$V_I = \text{GND}$	Single-ended or parallel output
$V_I = \text{REF}$	Normal push-pull operation

AVAILABLE OPTIONS

T <sub>A</sub>	PACKAGED DEVICES		CHIP FORM (Y)
	SMALL OUTLINE (D)	PLASTIC DIP (N)	
0°C to 70°C	TL598CD	TL598CN	TL598Y
-40°C to 125°C	TL598QD	-	

Chip forms are tested at 25°C.

## functional block diagram



# TL598 PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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## absolute maximum ratings over operating free-air temperature range (unless otherwise noted)<sup>†</sup>

Supply voltage, $V_{CC}$ (see Note 1)	41 V
Amplifier input voltage, $V_I$	$V_{CC} + 0.3$ V
Collector voltage	41 V
Output current (each output), sink or source, $I_O$	250 mA
Package thermal impedance, $\theta_{JA}$ (see Notes 2 and 3): D package	73°C/W
N package	88°C/W
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	260°C
Storage temperature range, $T_{stg}$	–65°C to 150°C

<sup>†</sup> 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.

- NOTES:
1. All voltage values, except differential voltages, are with respect to the signal ground terminal.
  2. Maximum power dissipation is a function of  $T_J(\max)$ ,  $\theta_{JA}$ , and  $T_A$ . The maximum allowable power dissipation at any allowable ambient temperature is  $P_D = (T_J(\max) - T_A)/\theta_{JA}$ . Operating at the absolute maximum  $T_J$  of 150°C can impact reliability.
  3. The package thermal impedance is calculated in accordance with JEDEC 51, except for through-hole packages, which use a trace length of zero.

## recommended operating conditions

	MIN	MAX	UNIT
Supply voltage, $V_{CC}$	7	40	V
Amplifier input voltage, $V_I$	0	$V_{CC} - 2$	V
Collector voltage		40	V
Output current (each output), sink or source, $I_O$		200	mA
Current into feedback terminal, $I_{FL}$		0.3	mA
Timing capacitor, $C_T$	0.00047	10	$\mu$ F
Timing resistor, $R_T$	1.8	500	k $\Omega$
Oscillator frequency, $f_{osc}$	1	300	kHz
Operating free-air temperature, $T_A$	TL598C	0	70
	TL598Q	–40	125

# TL598

## PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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

reference section (see Note 4)

PARAMETER	TEST CONDITIONST		TL598C			TL598Q			UNIT
			MIN	TYP‡	MAX	MIN	TYP‡	MAX	
Output voltage (REF)	$I_O = 1\text{ mA}$	$T_A = 25^\circ\text{C}$	4.95	5	5.05	4.95	5	5.05	V
		$T_A = \text{full range}$	4.9		5.1	4.9		5.1	
Input regulation	$V_{CC} = 7\text{ V to }40\text{ V}$	$T_A = 25^\circ\text{C}$	2		25	2		22	mV
Output regulation	$I_O = 1\text{ mA to }10\text{ mA}$	$T_A = 25^\circ\text{C}$	1		15	1		15	mV
		$T_A = \text{full range}$			50			80	
Output voltage change with temperature	$\Delta T_A = \text{MIN to MAX}$		2		10	2		10	mV/V
Short-circuit output current§	REF = 0 V		-10	-48		-10	-48		mA

† Full range is  $0^\circ\text{C}$  to  $70^\circ\text{C}$  for the TL598C, and  $-40^\circ\text{C}$  to  $125^\circ\text{C}$  for the TL598Q.

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

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

NOTE 4: Pulse-testing techniques that maintain the junction temperature as close to the ambient temperature as possible must be used.

**oscillator section,  $C_T = 0.001\ \mu\text{F}$ ,  $R_T = 12\ \text{k}\Omega$  (see Figure 1) (see Note 4)**

PARAMETER	TEST CONDITIONST	TL598C, TL598Q			UNIT
		MIN	TYP‡	MAX	
Frequency		100			kHz
Standard deviation of frequency¶	All values of $V_{CC}$ , $C_T$ , $R_T$ , $T_A$ constant	100			Hz/kHz
Frequency change with voltage	$V_{CC} = 7\text{ V to }40\text{ V}$ , $T_A = 25^\circ\text{C}$	1		10	Hz/kHz
Frequency change with temperature#	$\Delta T_A = \text{full range}$	70		120	Hz/kHz
	$\Delta T_A = \text{full range}$ , $C_T = 0.01\ \mu\text{F}$	50		80	

† Full range is  $0^\circ\text{C}$  to  $70^\circ\text{C}$  for the TL598C, and  $-40^\circ\text{C}$  to  $125^\circ\text{C}$  for the TL598Q.

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

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

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

# Effects of temperature on external  $R_T$  and  $C_T$  are not taken into account.

NOTE 4: Pulse-testing techniques that maintain the junction temperature as close to the ambient temperature as possible must be used.

**error amplifier section (see Note 4)**

PARAMETER	TEST CONDITIONS	TL598C, TL598Q			UNIT
		MIN	TYP‡	MAX	
Input offset voltage	FEEDBACK = 2.5 V	2		10	mV
Input offset current	FEEDBACK = 2.5 V	25		250	nA
Input bias current	FEEDBACK = 2.5 V	0.2		1	$\mu\text{A}$
Common-mode input voltage range	$V_{CC} = 7\text{ V to }40\text{ V}$	0 to $V_{CC}-2$			V
Open-loop voltage amplification	$\Delta V_O$ (FEEDBACK) = 3 V, $V_O$ (FEEDBACK) = 0.5 V to 3.5 V	70	95		dB
Unity-gain bandwidth		800			kHz
Common-mode rejection ratio	$V_{CC} = 40\text{ V}$ , $\Delta V_{IC} = 6.5\text{ V}$ , $T_A = 25^\circ\text{C}$	65	80		dB
Output sink current (FEEDBACK)	FEEDBACK = 0.5 V	0.3	0.7		mA
Output source current (FEEDBACK)	FEEDBACK = 3.5 V	-2			mA
Phase margin at unity gain	FEEDBACK = 0.5 V to 3.5 V, $R_L = 2\ \text{k}\Omega$	65°			
Supply-voltage rejection ratio	FEEDBACK = 2.5 V, $\Delta V_{CC} = 33\text{ V}$ , $R_L = 2\ \text{k}\Omega$	100			dB

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

NOTE 4: Pulse-testing techniques that maintain the junction temperature as close to the ambient temperature as possible must be used.

# TL598

## PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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

### undervoltage lockout section (see Note 4)

PARAMETER	TEST CONDITIONS†	TL598C		TL598Q		UNIT
		MIN	MAX	MIN	MAX	
Threshold voltage	$T_A = 25^\circ\text{C}$	4	6	4	6	V
	$\Delta T_A = \text{full range}$	3.5	6.9	3	6.9	
Hysteresis‡	$T_A = 25^\circ\text{C}$	100		100		mV
	$T_A = \text{full range}$	50		30		

† Full range is  $0^\circ\text{C}$  to  $70^\circ\text{C}$  for the TL598C, and  $-40^\circ\text{C}$  to  $125^\circ\text{C}$  for the TL598Q.

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

NOTE 4. Pulse-testing techniques must be used that maintain the junction temperature as close to the ambient temperature as possible.

### output section (see Note 4)

PARAMETER	TEST CONDITIONS	TL598C, TL598Q		UNIT
		MIN	MAX	
High-level output voltage	$V_{CC} = 15\text{ V}$ , $V_C = 15\text{ V}$	$I_O = -200\text{ mA}$	12	V
		$I_O = -20\text{ mA}$	13	
Low-level output voltage	$V_{CC} = 15\text{ V}$ , $V_C = 15\text{ V}$	$I_O = 200\text{ mA}$	2	V
		$I_O = 20\text{ mA}$	0.4	
Output-control input current	$V_I = V_{ref}$ $V_I = 0.4\text{ V}$		3.5	mA
			100	$\mu\text{A}$

NOTE 4. Pulse-testing techniques must be used that maintain the junction temperature as close to the ambient temperature as possible.

### dead-time control section (see Figure 1) (see Note 4)

PARAMETER	TEST CONDITIONS	TL598C			TL598Q			UNIT
		MIN	TYP§	MAX	MIN	TYP§	MAX	
Input bias current (DTC)	$V_I = 0$ to $5.25\text{ V}$		-2	-10		-2	-25	$\mu\text{A}$
Maximum duty cycle, each output	DTC = $0\text{ V}$	0.45			0.45			
Input threshold voltage (DTC)	Zero duty cycle		3	3.3		3	3.2	V
	Maximum duty cycle	0			0			

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

NOTE 4. Pulse-testing techniques must be used that maintain the junction temperature as close to the ambient temperature as possible.

### pwm comparator section (see Note 4)

PARAMETER	TEST CONDITIONS	TL598C, TL598Q			UNIT
		MIN	TYP§	MAX	
Input threshold voltage (FEEDBACK)	DTC = $0\text{ V}$		3.75	4.5	V
Input sink current (FEEDBACK)	$V(\text{FEEDBACK}) = 0.5\text{ V}$	0.3	0.7		mA

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

NOTE Pulse-testing techniques must be used that maintain the junction temperature as close to the ambient temperature as possible.

### total device (see Figure 1) (see Note 4)

PARAMETER	TEST CONDITIONS	TL598C, TL598Q			UNIT
		MIN	TYP§	MAX	
Standby supply current	RT = $V_{ref}$ , All other inputs and outputs open	$V_{CC} = 15\text{ V}$	15	21	mA
		$V_{CC} = 40\text{ V}$	20	26	
Average supply current	DTC = $2\text{ V}$	15			mA

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

NOTE 4. Pulse-testing techniques must be used that maintain the junction temperature as close to the ambient temperature as possible.

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## PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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

**switching characteristics,  $T_A = 25^\circ\text{C}$  (see Note 4)**

PARAMETER	TEST CONDITIONS	TL598C, TL598Q			UNIT
		MIN	TYP	MAX	
Output-voltage rise time	CL = 1500 pF, VC = 15 V, VCC = 15 V, See Figure 2		60	150	ns
Output-voltage fall time			35	75	

NOTE 4. Pulse-testing techniques must be used that maintain the junction temperature as close to the ambient temperature as possible.

**electrical characteristics,  $V_{CC} = 15\text{ V}$ ,  $T_A = 25^\circ\text{C}$**

**reference section (see Note 4)**

PARAMETER	TEST CONDITIONS	TL598Y			UNIT
		MIN	TYP†	MAX	
Output voltage (REF)	$I_O = 1\text{ mA}$		5		V
Input regulation	$V_{CC} = 7\text{ V to }40\text{ V}$		2		mV
Output regulation	$I_O = 1\text{ mA to }10\text{ mA}$		1		mV
Output-voltage change with temperature			2		mV/V
Short-circuit output current‡	REF = 0 V		-48		mA

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

‡ Duration of the short circuit should not exceed one second.

NOTE 4. Pulse-testing techniques that maintain the junction temperature as close to the ambient temperature as possible must be used.

**oscillator section,  $C_T = 0.001\ \mu\text{F}$ ,  $R_T = 12\text{ k}\Omega$  (see Figure 1) (see Note 4)**

PARAMETER	TEST CONDITIONS	TL598Y			UNIT
		MIN	TYP	MAX	
Frequency			100		kHz
Standard deviation of frequency§	All values of $V_{CC}$ , $C_T$ , $R_T$ , $T_A$ constant		100		Hz/kHz
Frequency change with voltage	$V_{CC} = 7\text{ V to }40\text{ V}$ ,		1		Hz/kHz

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

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

NOTE 4. Pulse-testing techniques that maintain the junction temperature as close to the ambient temperature as possible must be used.

**error amplifier section (see Note 4)**

PARAMETER	TEST CONDITIONS	TL598Y			UNIT
		MIN	TYP	MAX	
Input offset voltage	Feedback = 2.5 V		2		mV
Input offset current	Feedback = 2.5 V		25		nA
Input bias current	Feedback = 2.5 V		0.2		$\mu\text{A}$
Open-loop voltage amplification	$\Delta V_O$ (FEEDBACK) = 3 V, $V_O$ (FEEDBACK) = 0.5 V to 3.5 V		95		dB
Unity-gain bandwidth			800		kHz
Common-mode rejection ratio	$V_{CC} = 40\text{ V}$ , $\Delta V_{IC} = 6.5\text{ V}$ ,		80		dB
Output sink current (FEEDBACK)	FEEDBACK = 0.5 V		0.7		mA
Phase margin at unity gain	FEEDBACK = 0.5 V to 3.5 V, $R_L = 2\text{ k}\Omega$		65°		
Supply-voltage rejection ratio	FEEDBACK = 2.5 V, $\Delta V_{CC} = 33\text{ V}$ , $R_L = 2\text{ k}\Omega$		100		dB

NOTE 4. Pulse-testing techniques that maintain the junction temperature as close to the ambient temperature as possible must be used.

# TL598 PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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**electrical characteristics,  $V_{CC} = 15\text{ V}$ ,  $T_A = 25^\circ\text{C}$**

**dead-time control section (see Figure 1) (see Note 4)**

PARAMETER	TEST CONDITIONS	TL598Y			UNIT
		MIN	TYP	MAX	
Input bias current (DTC)	$V_I = 0$ to $5.25\text{ V}$		-2		$\mu\text{A}$
Input threshold voltage (DTC)	Zero duty cycle		3		V

NOTE 4. Pulse-testing techniques that maintain the junction temperature as close to the ambient temperature as possible must be used.

**pwm comparator section (see Note 4)**

PARAMETER	TEST CONDITIONS	TL598Y			UNIT
		MIN	TYP	MAX	
Input threshold voltage (FEEDBACK)	DTC = $0\text{ V}$		3.75		V
Input sink current (FEEDBACK)	FEEDBACK = $0.5\text{ V}$		0.7		mA

NOTE 4. Pulse-testing techniques that maintain the junction temperature as close to the ambient temperature as possible must be used.

**total device (see Figure 1) (see Note 4)**

PARAMETER	TEST CONDITIONS		TL598Y			UNIT
			MIN	TYP	MAX	
Standby supply current	RT = $V_{ref}$ , All other inputs and outputs open	$V_{CC} = 15\text{ V}$		15		mA
		$V_{CC} = 40\text{ V}$		20		
Average supply current	DTC = $2\text{ V}$			15		mA

NOTE 4. Pulse-testing techniques that maintain the junction temperature as close to the ambient temperature as possible must be used.

# TL598 PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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## PARAMETER MEASUREMENT INFORMATION

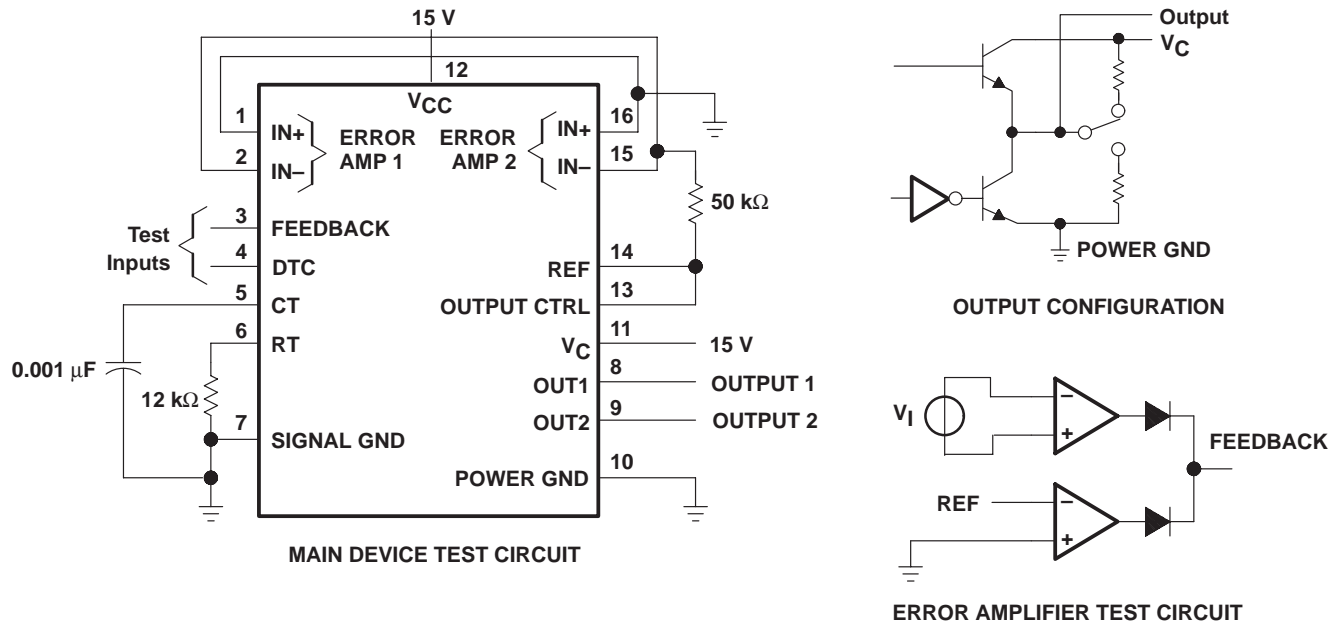


Figure 1. Test Circuits

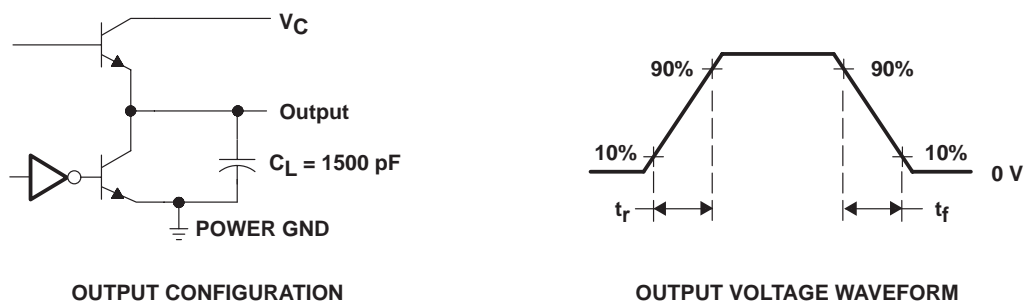
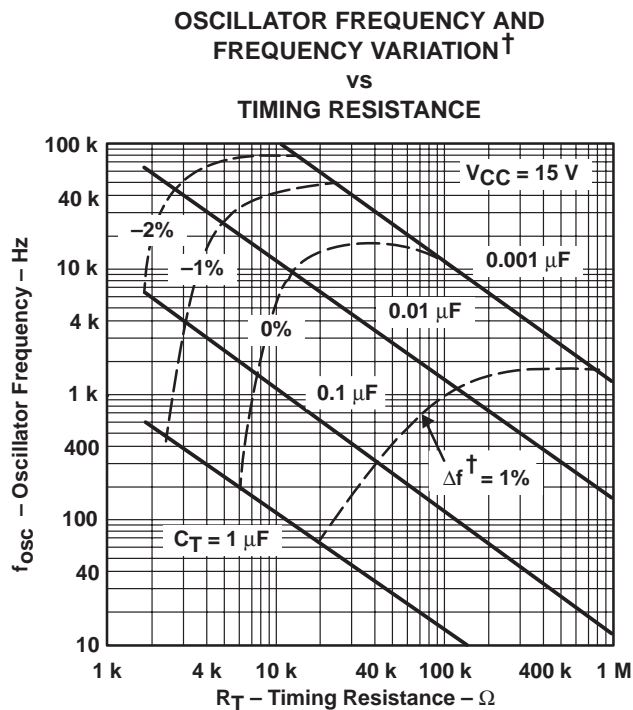


Figure 2. Switching Output Configuration and Voltage Waveform



TYPICAL CHARACTERISTICS



<sup>†</sup> Frequency variation ( $\Delta f$ ) is the change in predicted oscillator frequency that occurs over the full temperature range.

Figure 3

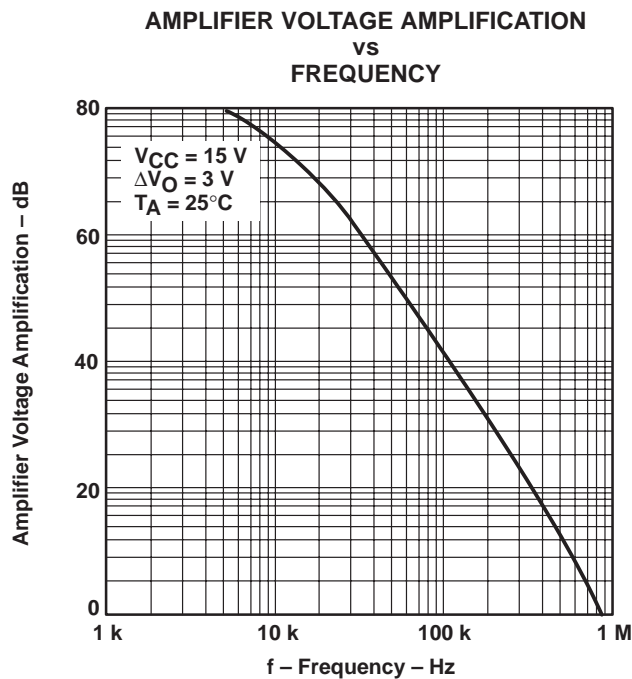


Figure 4

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