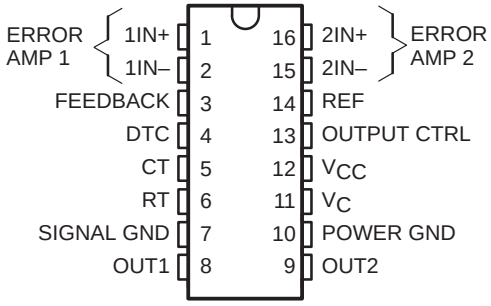
SLVS053C – FEBRUARY 1988 – REVISED JULY 1999

- **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°C to 125°C**

D OR N PACKAGE
(TOP VIEW)



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 $\left(f_O = \frac{1}{2\ RT\ CT}\right)$. For single-ended applications: $f_O = \frac{1}{RT\ CT}$.

The TL598C is characterized for operation from 0°C to 70°C. The TL598Q is characterized for operation from –40°C to 125°C.

FUNCTION TABLE

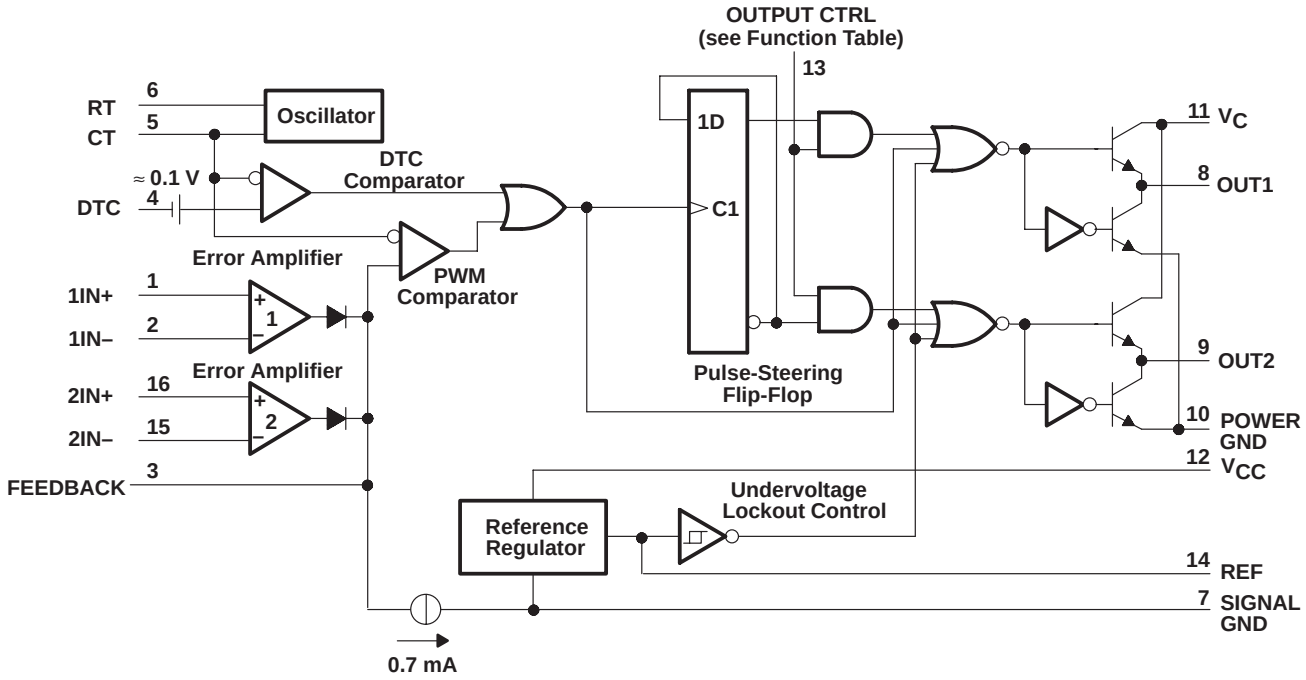
INPUT/OUTPUT CTRL	OUTPUT FUNCTION
V_I = GND	Single-ended or parallel output
V_I = REF	Normal push-pull operation

AVAILABLE OPTIONS

T_A	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



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

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, θ_{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

† 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 $T_J(max)$, θ_{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 JESD 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_{IL}			0.3	mA
Timing capacitor, C_T		0.00047	10	μF
Timing resistor, R_T		1.8	500	kΩ
Oscillator frequency, f_{osc}		1	300	kHz
Operating free-air temperature, T_A	TL598C	0	70	°C
	TL598Q	–40	125	

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

reference section (see Note 4)

PARAMETER	TEST CONDITIONS†		TL598C			TL598Q			UNIT
			MIN	TYP‡	MAX	MIN	TYP‡	MAX	
Output voltage (REF)	I_O = 1 mA	T_A = 25°C	4.95	5	5.05	4.95	5	5.05	V
		T_A = full range	4.9		5.1	4.9		5.1	
Input regulation	V_{CC} = 7 V to 40 V	T_A = 25°C		2	25		2	22	mV
Output regulation	I_O = 1 mA to 10 mA	T_A = 25°C		1	15		1	15	mV
		T_A = full range			50			80	
Output voltage change with temperature	ΔT_A = 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°C to 70°C for the TL598C, and –40°C to 125°C for the TL598Q.
‡ 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.
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 μF, R_T = 12 kΩ (see Figure 1) (see Note 4)

PARAMETER	TEST CONDITIONS†	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 V to 40 V, T_A = 25°C		1	10	Hz/kHz
Frequency change with temperature#	ΔT_A = full range		70	120	Hz/kHz
	ΔT_A = full range, C_T = 0.01 μF		50	80	

† Full range is 0°C to 70°C for the TL598C, and –40°C to 125°C for the TL598Q.
‡ All typical values except for parameter changes with temperature are at T_A = 25°C.
¶ Standard deviation is a measure of the statistical distribution about the mean as derived from the formula:

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

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	μA
Common-mode input voltage range	V_{CC} = 7 V to 40 V	0 to V_{CC}–2			V
Open-loop voltage amplification	ΔV_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 V, ΔV_{IC} = 6.5 V, T_A = 25°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 kΩ		65°		
Supply-voltage rejection ratio	FEEDBACK = 2.5 V, ΔV_{CC} = 33 V, R_L = 2 kΩ		100		dB

‡ All typical values except for parameter changes with temperature are at T_A = 25°C.
NOTE 4. Pulse-testing techniques that maintain the junction temperature as close to the ambient temperature as possible must be used.

electrical characteristics over recommended operating free-air temperature range, V_{CC} = 15 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°C	4	6	4	6	V
	ΔT_A = full range	3.5	6.9	3	6.9	
Hysteresis‡	T_A = 25°C	100		100		mV
	T_A = full range	50		30		

† Full range is 0°C to 70°C for the TL598C, and –40°C to 125°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 V, V_C = 15 V	I_O = –200 mA	12		V
		I_O = –20 mA	13		
Low-level output voltage	V_{CC} = 15 V, V_C = 15 V	I_O = 200 mA		2	V
		I_O = 20 mA		0.4	
Output-control input current	V_I = V_{ref}			3.5	mA
	V_I = 0.4 V			100	µA

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 V		–2	–10		–2	–25	µA
Maximum duty cycle, each output	DTC = 0 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°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 V		3.75	4.5	V
Input sink current (FEEDBACK)	$V_{(FEEDBACK)}$ = 0.5 V	0.3	0.7		mA

§ All typical values except for parameter changes with temperature are at T_A = 25°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 V		15	21	mA
		V_{CC} = 40 V		20	26	
Average supply current	DTC = 2 V			15		mA

§ All typical values except for parameter changes with temperature are at T_A = 25°C.
NOTE 4. Pulse-testing techniques must be used that maintain the junction temperature as close to the ambient temperature as possible.

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

switching characteristics, T_A = 25°C (see Note 4)

PARAMETER	TEST CONDITIONS			TL598C, TL598Q			UNIT
				MIN	TYP	MAX	
Output-voltage rise time	CL = 1500 pF, See Figure 2	VC = 15 V,	VCC = 15 V,		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 V, T_A = 25°C

reference section (see Note 4)

PARAMETER	TEST CONDITIONS	TL598Y			UNIT
		MIN	TYP†	MAX	
Output voltage (REF)	I_O = 1 mA		5		V
Input regulation	V_{CC} = 7 V to 40 V		2		mV
Output regulation	I_O = 1 mA to 10 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°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 μF, R_T = 12 kΩ (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 V to 40 V,		1		Hz/kHz

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

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

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		μA
Open-loop voltage amplification	ΔV_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 V,	ΔV_{IC} = 6.5 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 kΩ		65°		
Supply-voltage rejection ratio	FEEDBACK = 2.5 V,	ΔV_{CC} = 33 V,	R_L = 2 kΩ		100		dB

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

electrical characteristics, V_{CC} = 15 V, T_A = 25°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 V		–2		μA
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 V		3.75		V
Input sink current (FEEDBACK)	FEEDBACK = 0.5 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 V		15		mA
		V_{CC} = 40 V		20		
Average supply current	DTC = 2 V			15		mA

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

PARAMETER MEASUREMENT INFORMATION

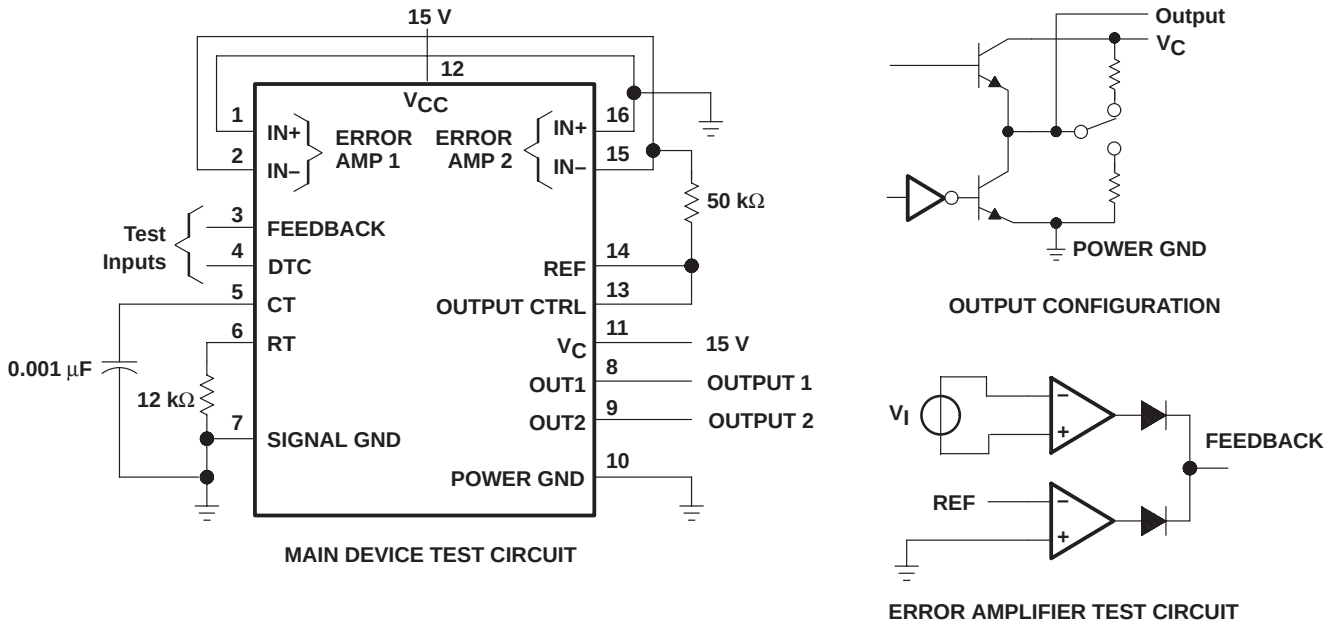


Figure 1. Test Circuits

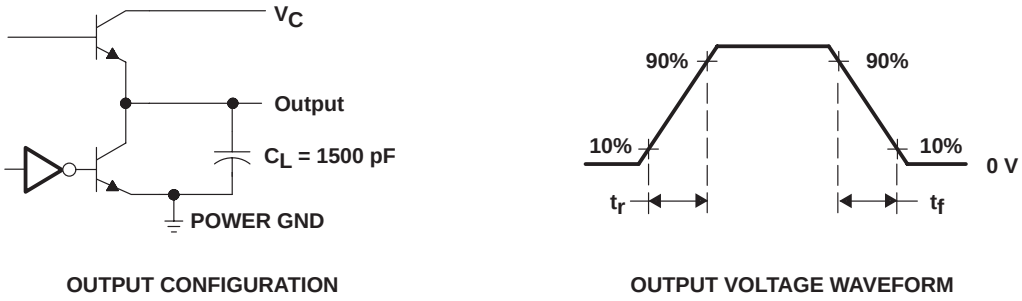
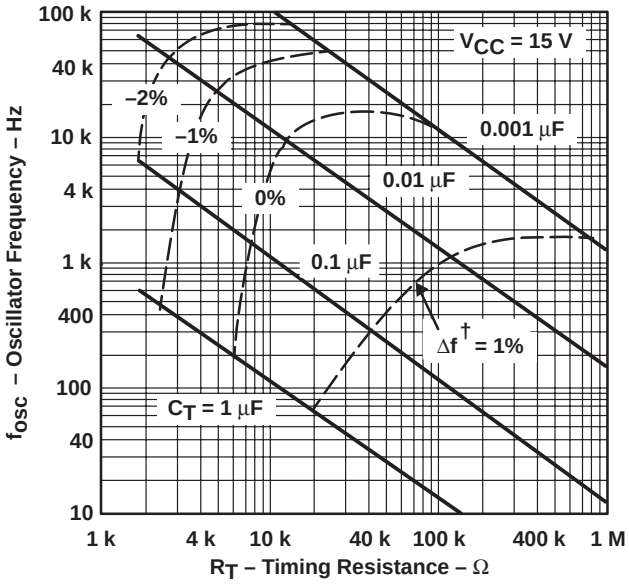


Figure 2. Switching Output Configuration and Voltage Waveform

TYPICAL CHARACTERISTICS

OSCILLATOR FREQUENCY AND FREQUENCY VARIATION† vs TIMING RESISTANCE



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

Figure 3

AMPLIFIER VOLTAGE AMPLIFICATION vs FREQUENCY

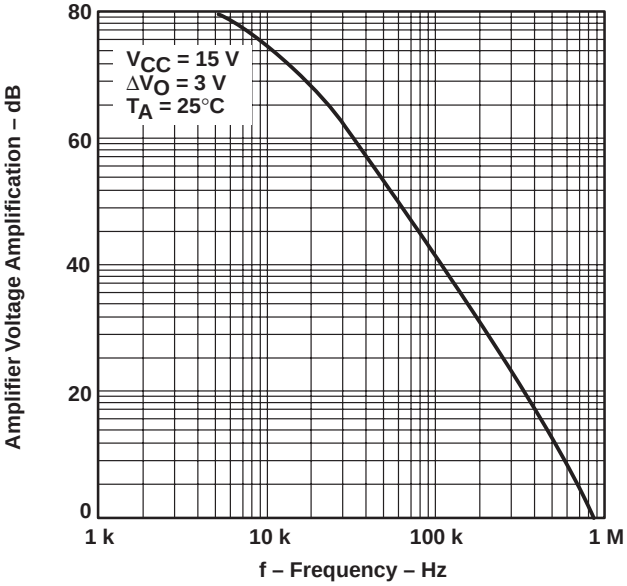


Figure 4

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