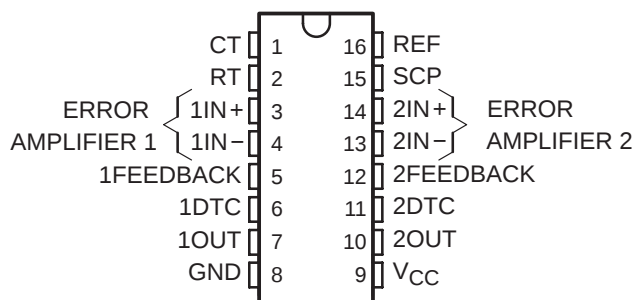


TL1451A-Q1 DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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- Qualified for Automotive Applications
- Complete PWM Power Control Circuitry
- Completely Synchronized Operation
- Internal Undervoltage Lockout Protection
- Wide Supply Voltage Range
- Internal Short-Circuit Protection
- Oscillator Frequency . . . 500 kHz Max
- Variable Dead Time Provides Control Over Total Range
- Internal Regulator Provides a Stable 2.5-V Reference Supply
- Available in Q-Temp Automotive HighRel Automotive Applications Configuration Control / Print Support Qualification to Automotive Standards

PW PACKAGE
(TOP VIEW)



description

The TL1451A incorporates on a single monolithic chip all the functions required in the construction of two pulse-width-modulation (PWM) control circuits. Designed primarily for power-supply control, the TL1451A contains an on-chip 2.5-V regulator, two error amplifiers, an adjustable oscillator, two dead-time comparators, undervoltage lockout circuitry, and dual common-emitter output transistor circuits.

The uncommitted output transistors provide common-emitter output capability for each controller. The internal amplifiers exhibit a common-mode voltage range from 1.04 V to 1.45 V. The dead-time control (DTC) comparator has no offset unless externally altered and can provide 0% to 100% dead time. The on-chip oscillator can be operated by terminating RT and CT. During low V_{CC} conditions, the undervoltage lockout control circuit feature locks the outputs off until the internal circuitry is operational.

The TL1451A is characterized for operation from -40°C to 125°C .

AVAILABLE OPTIONS[†]

T _A	PACKAGED DEVICES [‡]
	TSSOP (PW) [§]
-40°C to 125°C	TL1451AQPWRQ1

[†] For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at <http://www.ti.com>.

[‡] Package drawings, thermal data, and symbolization are available at <http://www.ti.com/packaging>.

[§] The PW package is only available left-end taped and reeled.



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.

PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

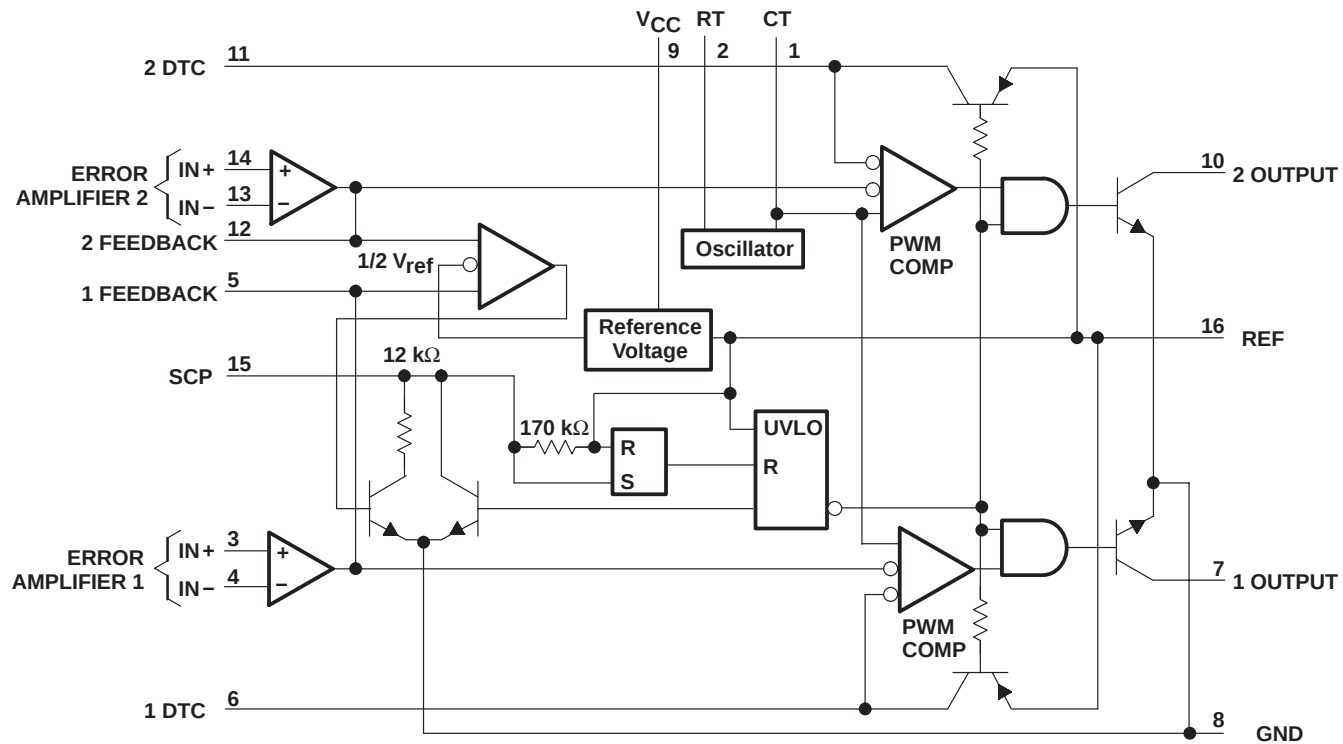
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On products compliant to MIL-PRF-38535, all parameters are tested unless otherwise noted. On all other products, production processing does not necessarily include testing of all parameters.

TL1451A-Q1

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functional block diagram



COMPONENT COUNT

Resistors	65
Capacitors	8
Transistors	105
JFETs	18

TL1451A-Q1 DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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absolute maximum ratings over operating free-air temperature range[†]

Supply voltage, V_{CC}	51 V
Amplifier input voltage, V_I	20 V
Collector output voltage, V_O	51 V
Collector output current, I_O	21 mA
Continuous power total dissipation	See Dissipation Rating Table
Operating free-air temperature range, T_A	-40°C to 125°C
Storage temperature range, T_{stg}	-65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	260°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.

DISSIPATION RATING TABLE

PACKAGE	$T_A \leq 25^\circ\text{C}$ POWER RATING	DERATING FACTOR ABOVE $T_A = 25^\circ\text{C}$	$T_A = 70^\circ\text{C}$ POWER RATING	$T_A = 85^\circ\text{C}$ POWER RATING	$T_A = 125^\circ\text{C}$ POWER RATING
PW	838 mW	6.7 mW/°C	536 mW	436 mW	168 mW

recommended operating conditions

	MIN	MAX	UNIT
Supply voltage, V_{CC}	3.6	50	V
Amplifier input voltage, V_I	1.05	1.45	V
Collector output voltage, V_O		50	V
Collector output current, I_O		20	mA
Current into feedback terminal		45	μA
Feedback resistor, R_F	100		kΩ
Timing capacitor, C_T	150	15000	pF
Timing resistor, R_T	5.1	100	kΩ
Oscillator frequency	1	500	kHz
Operating free-air temperature, T_A	-40	125	°C

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DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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electrical characteristics over recommended operating free-air temperature range, $V_{CC} = 6\text{ V}$, $f = 200\text{ kHz}$ (unless otherwise noted)

reference section

PARAMETER	TEST CONDITIONS		TL1451AQ			UNIT
			MIN	TYP†	MAX	
Output voltage (pin 16)	I _O = 1 mA	T _A = 25°C	2.4	2.5	2.6	V
		T _A = MIN and 125°C	2.35	2.46	2.65	
Output voltage change with temperature			−0.63%		±4%‡	
Input voltage regulation	V _{CC} = 3.6 V to 40 V	T _A = 25°C	2.0		12.5	mV
		T _A = 125°C	0.7		15	
		T _A = MIN	0.3		30	
Output voltage regulation	I _O = 0.1 mA to 1 mA	T _A = 25°C	1		7.5	mV
		T _A = 125°C	0.3		14	
		T _A = MIN	0.3		20	
Short-circuit output current	V _O = 0		3	10	30	mA

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

‡ These parameters are not production tested.

undervoltage lockout section

PARAMETER	TEST CONDITIONS	TL1451AQ			UNIT
		MIN	TYP†	MAX	
Upper threshold voltage (V_{CC})	$T_A = 25^\circ\text{C}$		2.72		V
	$T_A = 125^\circ\text{C}$		1.7		
	$T_A = \text{MIN}$		3.15		
Lower threshold voltage (V_{CC})	$T_A = 25^\circ\text{C}$		2.6		V
	$T_A = 125^\circ\text{C}$		1.65		
	$T_A = \text{MIN}$		3.09		
Hysteresis (V_{CC})	$T_A = 25^\circ\text{C}$	80	120		mV
	$T_A = 125^\circ\text{C}$	10	50		
	$T_A = \text{MIN}$	10	60		
Reset threshold voltage (V_{CC})	$T_A = 25^\circ\text{C}$		1.5		V
	$T_A = 125^\circ\text{C}$		0.95		
	$T_A = \text{MIN}$		1.5		

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

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short-circuit protection control section

PARAMETER	TEST CONDITIONS	TL1451AQ			UNIT
		MIN	TYP [†]	MAX	
Input threshold voltage (SCP)	T _A = 25°C	650	700	750	mV
	T _A = 125°C	400	478	650	
	T _A = MIN	800	880	950	
Standby voltage (SCP)		140	185	230	mV
Latched input voltage (SCP)	T _A = 25°C		60	120	mV
	T _A = 125°C		70	120	
	T _A = MIN		60	120	
Equivalent timing resistance			170		kΩ
Comparator threshold voltage (FEEDBACK)			1.18		V

[†] All typical values are at T_A = 25°C unless otherwise indicated.

oscillator section

PARAMETER	TEST CONDITIONS		TL1451AQ			UNIT
			MIN	TYP [†]	MAX	
Frequency	C _T = 330 pF, R _T = 10 kΩ	T _A = 25°C		200		kHz
		T _A = 125°C		195		
		T _A = MIN		193		
Standard deviation of frequency	C _T = 330 pF, R _T = 10 kΩ			2%		
Frequency change with voltage	V _{CC} = 3.6 V to 40 V	T _A = 25°C		1%		
		T _A = 125°C		1%		
		T _A = MIN		3%		
Frequency change with temperature				1.37%	±10% [‡]	

[†] All typical values are at T_A = 25°C unless otherwise indicated.

[‡] These parameters are not production tested.

dead-time control section

PARAMETER	TEST CONDITIONS	TL1451AQ			UNIT
		MIN	TYP [†]	MAX	
Input bias current (DTC)	T _A = 25°C			1	μA
	T _A = MIN and 125°C			3	
Latch mode (source) current (DTC)		-80	-145		μA
Latched input voltage (DTC)	T _A = 25°C		2.3		V
	T _A = 125°C		2.22	2.32	
	T _A = MIN		2.28	2.4	
Input threshold voltage at f = 10 kHz (DTC)	Zero duty cycle		2.05	2.25 [‡]	V
	Maximum duty cycle	1.2 [‡]	1.45		

[†] All typical values are at T_A = 25°C unless otherwise indicated.

[‡] These parameters are not production tested.

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DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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error-amplifier section

PARAMETER	TEST CONDITIONS	TL1451AQ			UNIT
		MIN	TYP [†]	MAX	
Input offset voltage	V_O (FEEDBACK) = 1.25 V	$T_A = 25^\circ\text{C}$		±7	mV
		$T_A = 125^\circ\text{C}$		±10	
		$T_A = \text{MIN}$		±12	
Input offset current	V_O (FEEDBACK) = 1.25 V	$T_A = 25^\circ\text{C}$		±100	nA
		$T_A = 125^\circ\text{C}$		±100	
		$T_A = \text{MIN}$		±200	
Input bias current	V_O (FEEDBACK) = 1.25 V	$T_A = 25^\circ\text{C}$	160	500	nA
		$T_A = 125^\circ\text{C}$	100	500	
		$T_A = \text{MIN}$	142	700	
Common-mode input voltage range	$V_{CC} = 3.6 \text{ V to } 40 \text{ V}$	1.05 to 1.45			V
Open-loop voltage amplification	$R_F = 200 \text{ k}\Omega$	$T_A = 25^\circ\text{C}$	70	80	dB
		$T_A = 125^\circ\text{C}$	70	80	
		$T_A = \text{MIN}$	64	80	
Unity-gain bandwidth			1.5		MHz
Common-mode rejection ratio		60	80		dB
Positive output voltage swing		2			V
Negative output voltage swing				1	V
Output (sink) current (FEEDBACK)	$V_{ID} = -0.1 \text{ V}, V_O = 1.25 \text{ V}$	$T_A = 25^\circ\text{C}$	0.5	1.6	mA
		$T_A = 125^\circ\text{C}$	0.4	1.8	
		$T_A = \text{MIN}$	0.3	1.7	
Output (source) current (FEEDBACK)	$V_{ID} = 0.1 \text{ V}, V_O = 1.25 \text{ V}$	$T_A = 25^\circ\text{C}$	-45	-70	μA
		$T_A = 125^\circ\text{C}$	-25	-50	
		$T_A = \text{MIN}$	-15	-70	

[†] All typical values are at $T_A = 25^\circ\text{C}$ unless otherwise indicated.

output section

PARAMETER	TEST CONDITIONS	TL1451AQ			UNIT
		MIN	TYP [†]	MAX	
Collector off-state current	$V_O = 50 \text{ V}$			10	μA
Output saturation voltage	$T_A = 25^\circ\text{C}$		1.2	2	V
	$T_A = 125^\circ\text{C}$		1.6	2.4	
	$T_A = \text{MIN}$		1.36	2.2	
Short-circuit output current	$V_O = 6 \text{ V}$		90		mA

[†] All typical values are at $T_A = 25^\circ\text{C}$ unless otherwise indicated.

pwm comparator section

PARAMETER	TEST CONDITIONS	TL1451AQ			UNIT
		MIN	TYP [†]	MAX	
Input threshold voltage at $f = 10 \text{ kHz}$ (FEEDBACK)	Zero duty cycle		2.05	2.25 [‡]	V
	Maximum duty cycle	1.2 [‡]	1.45		

[†] All typical values are at $T_A = 25^\circ\text{C}$ unless otherwise indicated.

[‡] These parameters are not production tested.

TL1451A-Q1 DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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total device

PARAMETER	TEST CONDITIONS	TL1451AQ			UNIT
		MIN	TYP [†]	MAX	
Standby supply current	Off-state		1.3	1.8	mA
Average supply current	$R_T = 10\text{ k}\Omega$		1.7	2.4	mA

[†] All typical values are at $T_A = 25^\circ\text{C}$ unless otherwise indicated.

PARAMETER MEASUREMENT INFORMATION

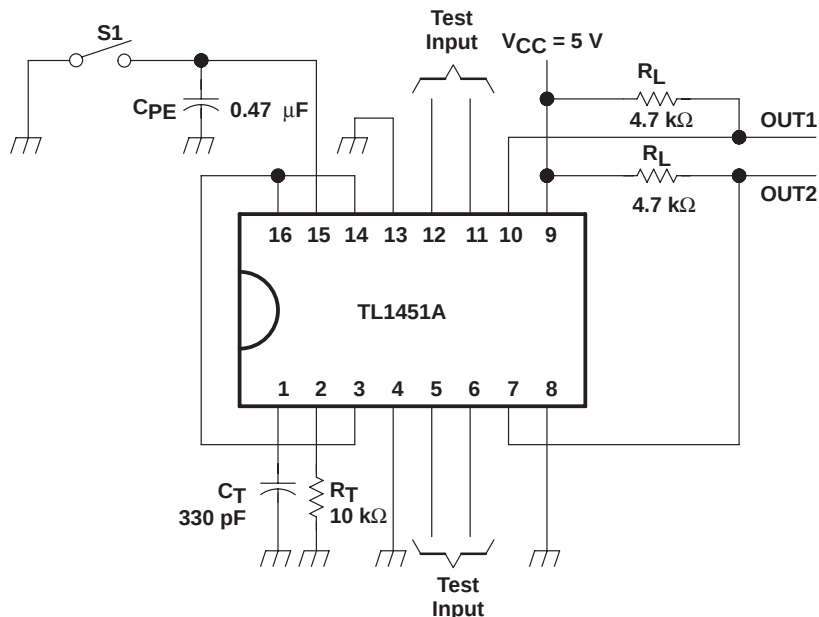
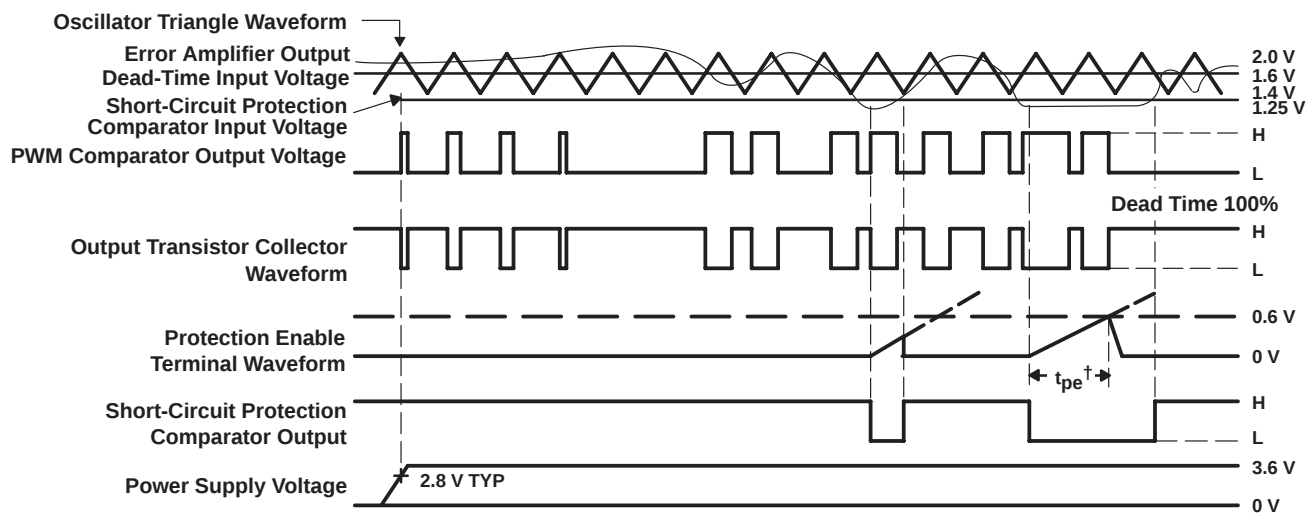


Figure 1. Test Circuit



[†] Protection Enable Time, $t_{pe} = (0.051 \times 10^6 \times C_{pe})$ in seconds

Figure 2. TL1451A Timing Diagram

TL1451A-Q1

DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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TYPICAL CHARACTERISTICS

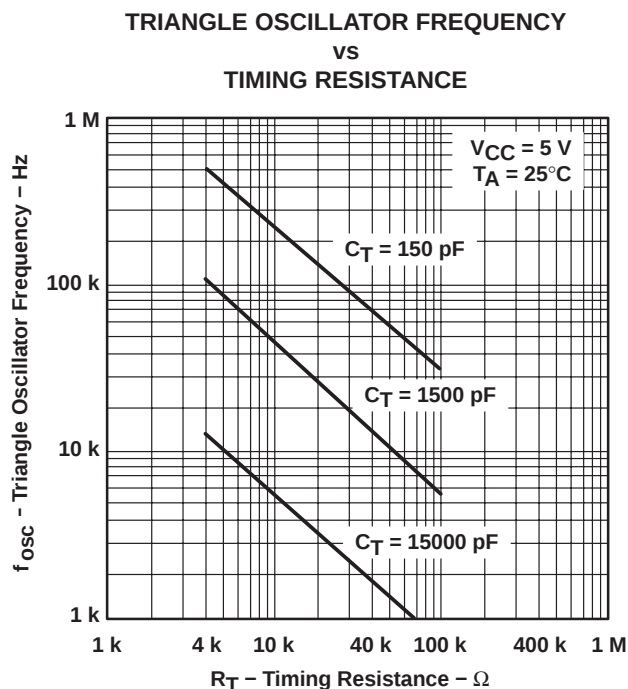


Figure 3

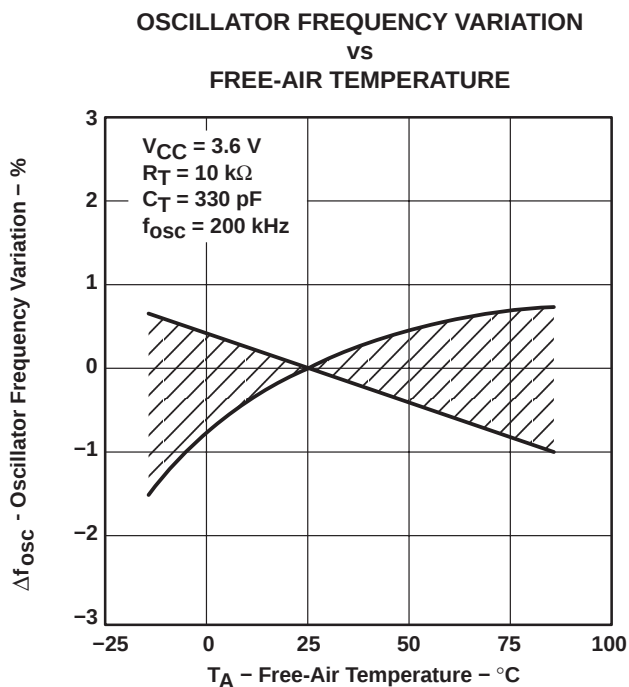


Figure 4

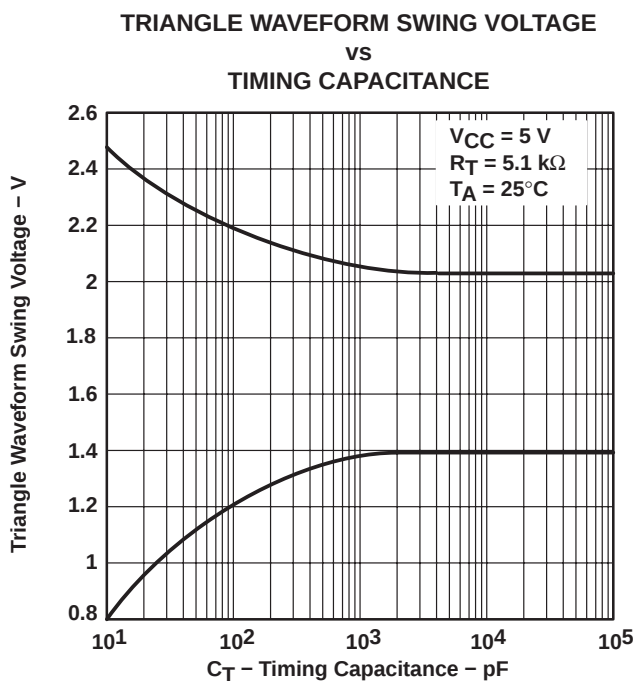


Figure 5

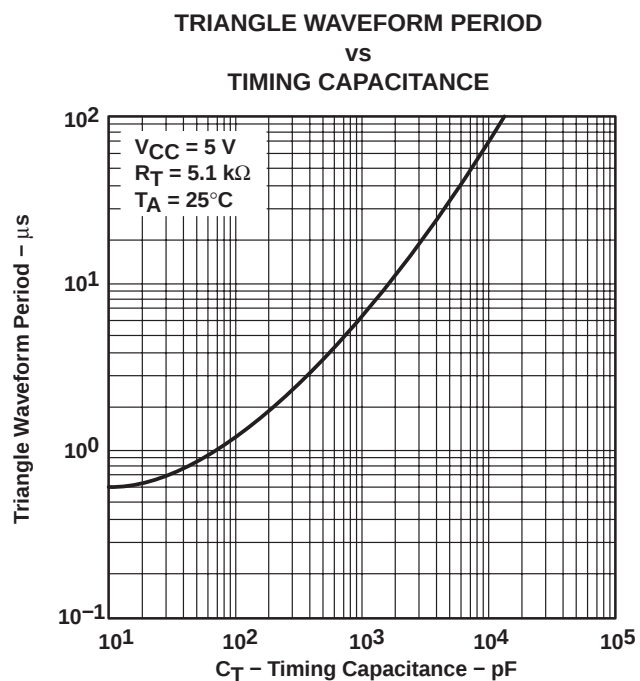


Figure 6

TYPICAL CHARACTERISTICS

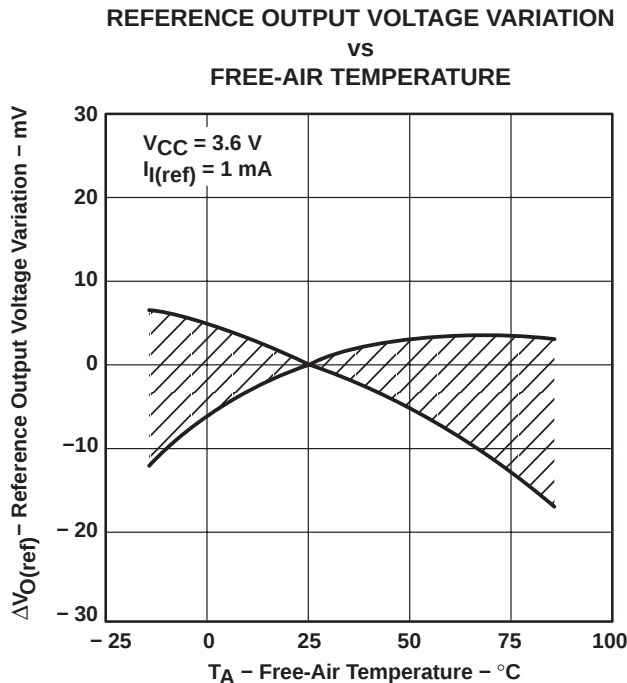


Figure 7

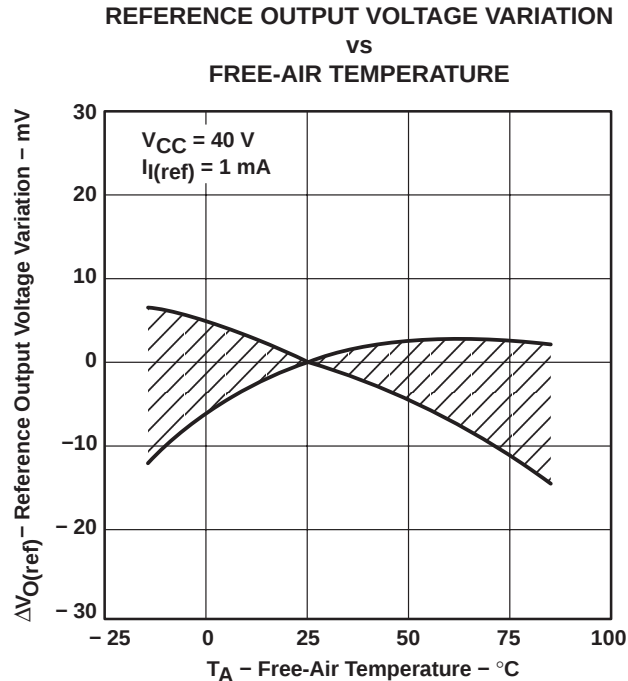


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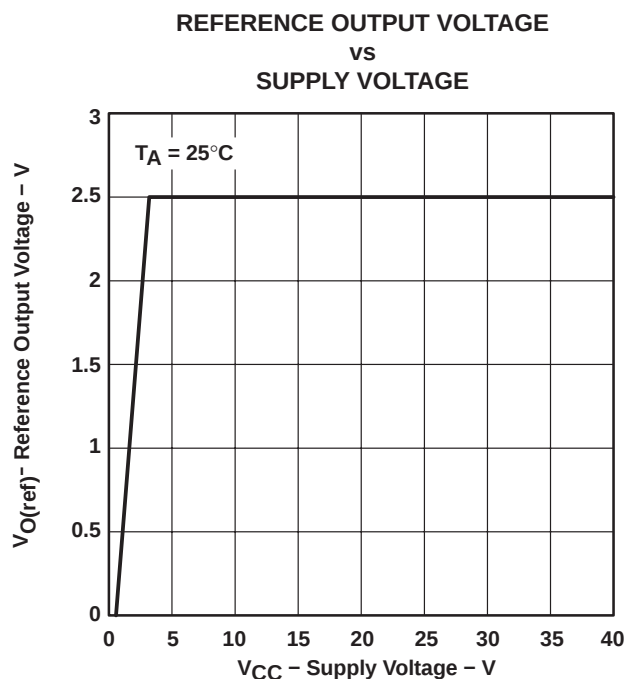


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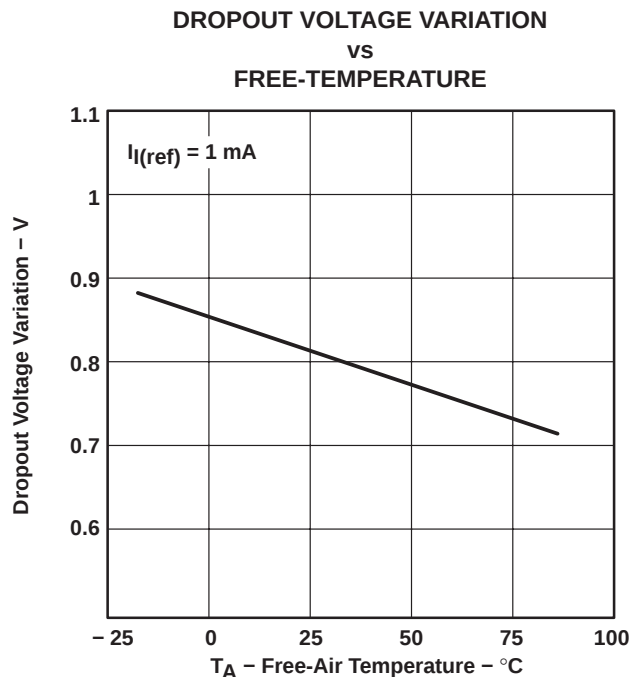


Figure 10

TL1451A-Q1

DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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TYPICAL CHARACTERISTICS

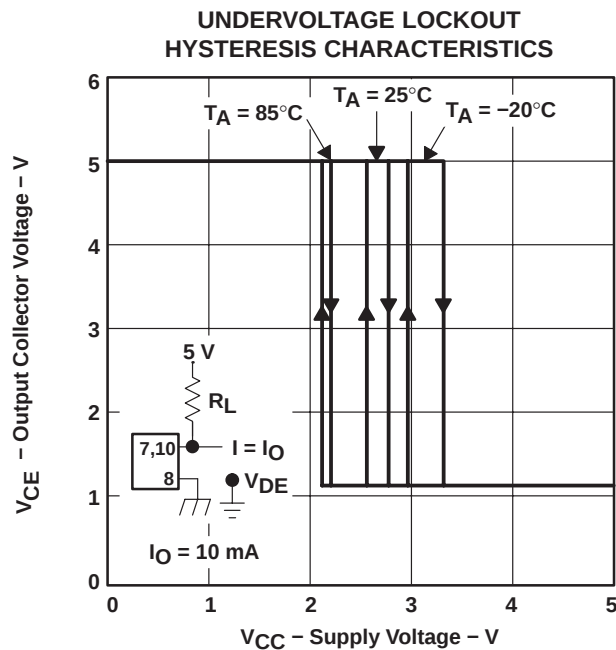


Figure 11

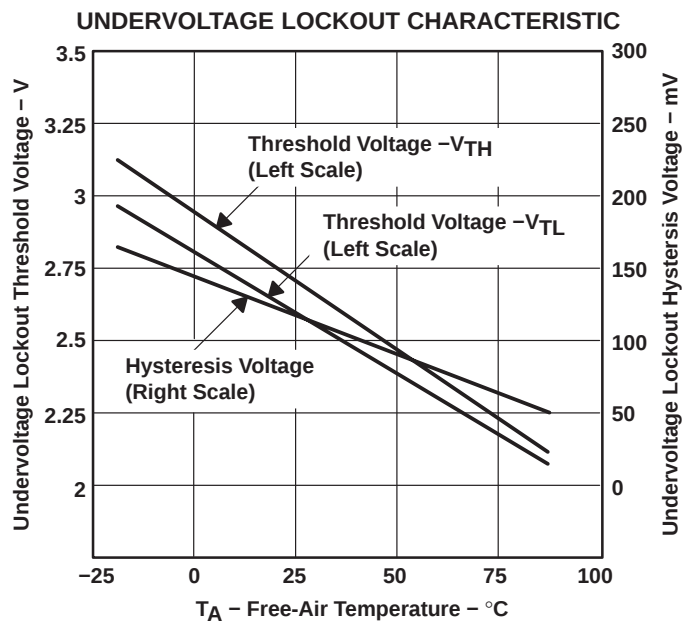


Figure 12

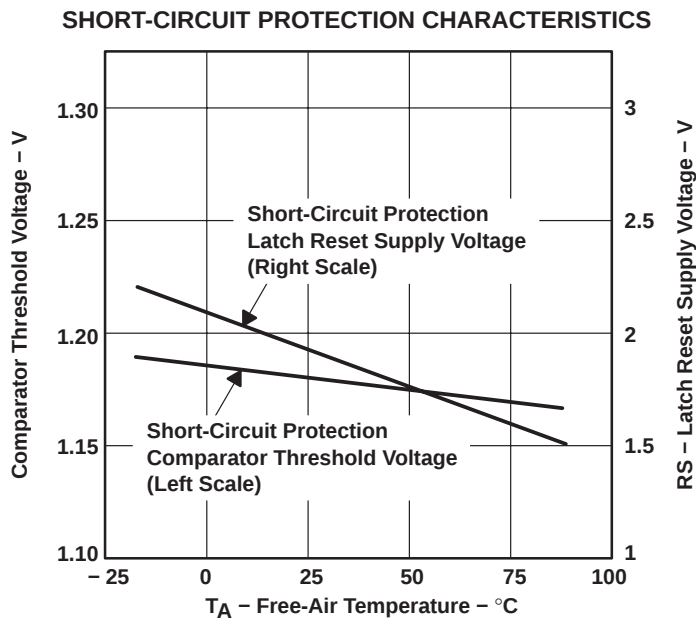


Figure 13

TYPICAL CHARACTERISTICS

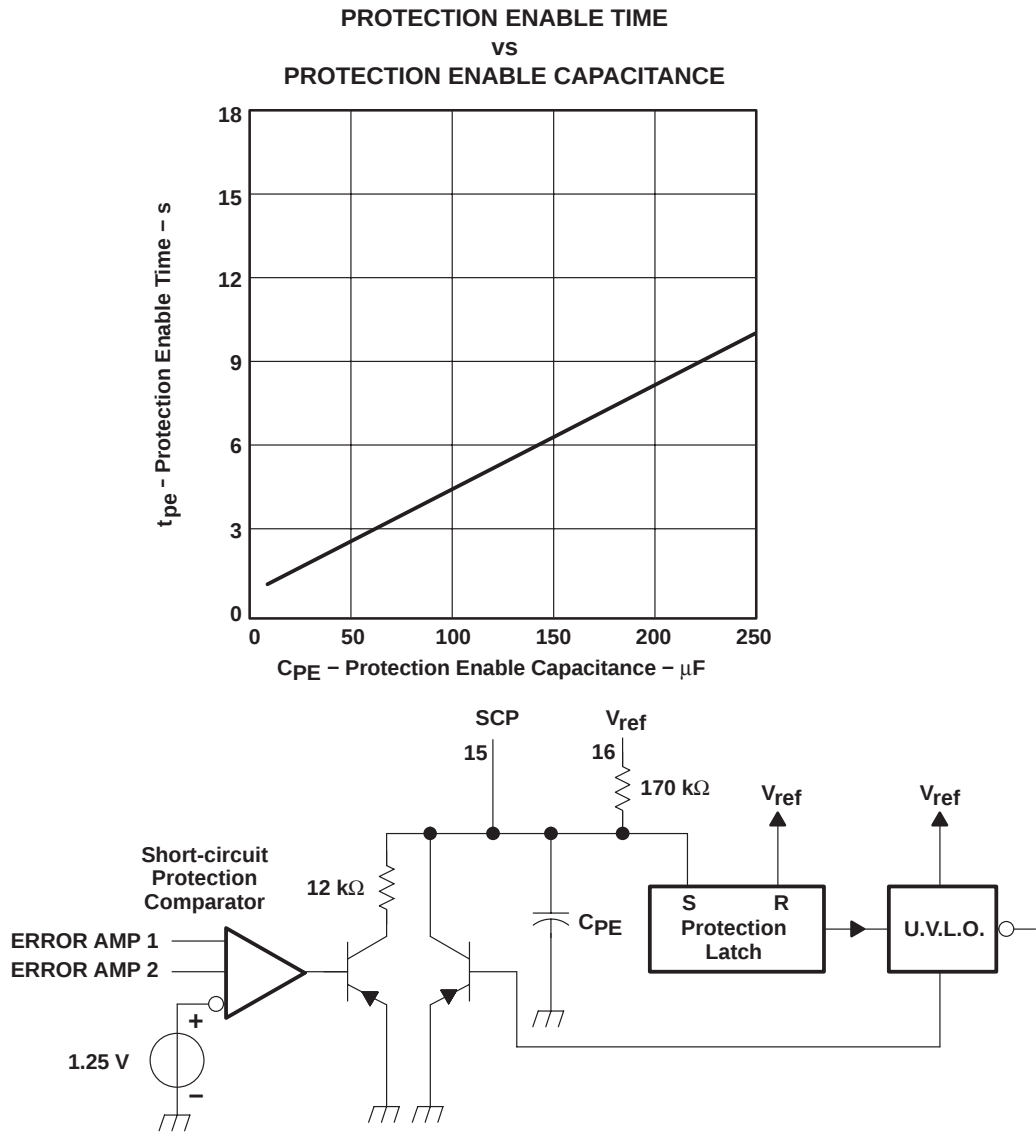


Figure 14

TL1451A-Q1

DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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TYPICAL CHARACTERISTICS

ERROR AMP MAXIMUM OUTPUT VOLTAGE SWING

VS
FREQUENCY

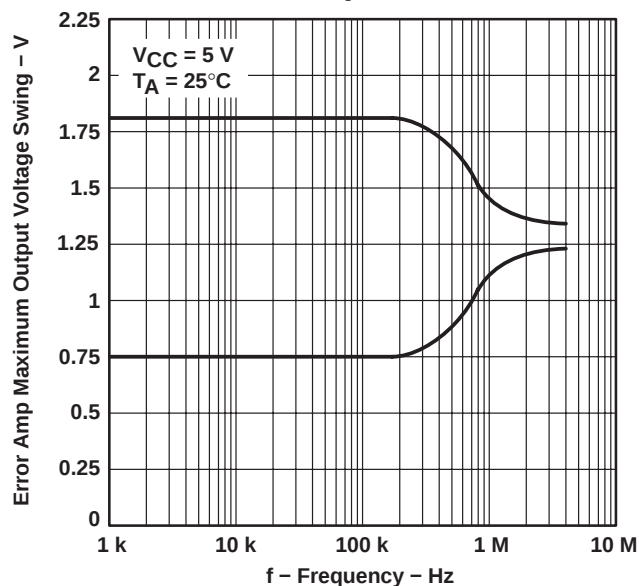


Figure 15

OPEN-LOOP VOLTAGE AMPLIFICATION

VS
FREQUENCY

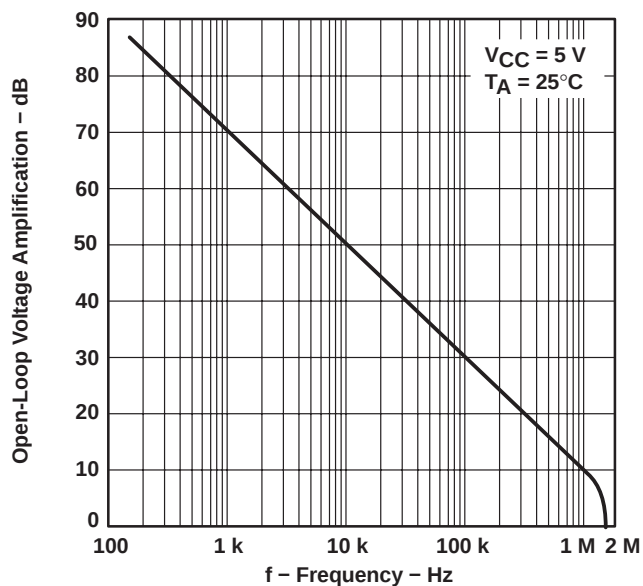


Figure 16

GAIN (AMPLIFIER IN
UNITY-GAIN CONFIGURATION)

VS
FREQUENCY

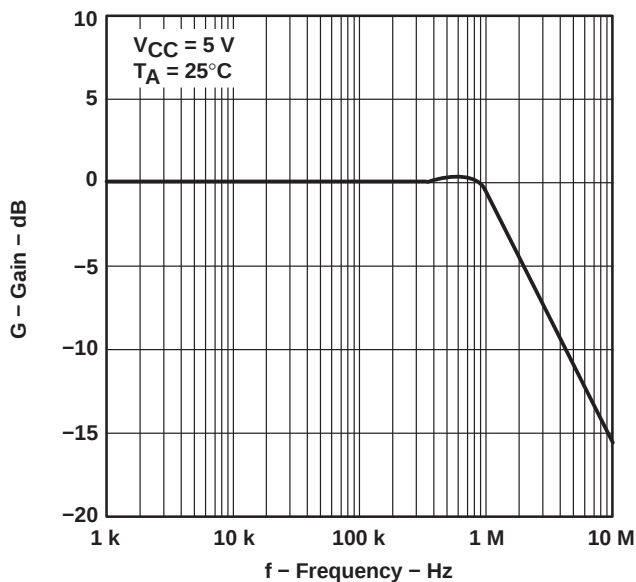
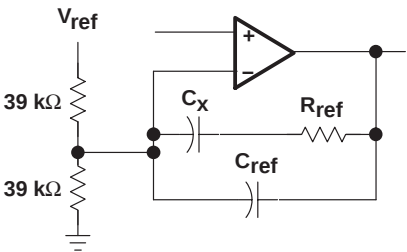
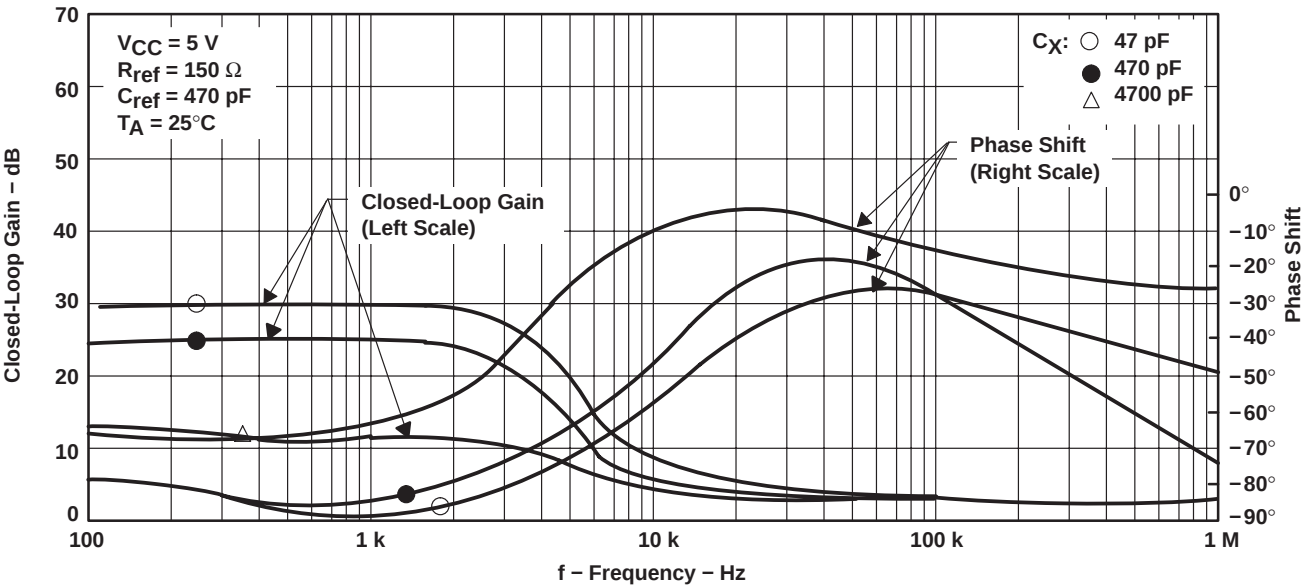


Figure 17

TYPICAL CHARACTERISTICS

CLOSED-LOOP GAIN AND PHASE SHIFT
VS
FREQUENCY



Test Circuit

Figure 18

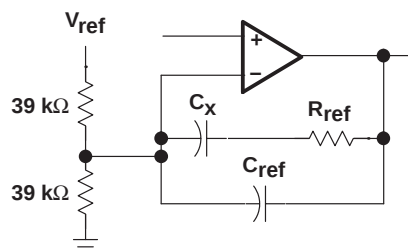
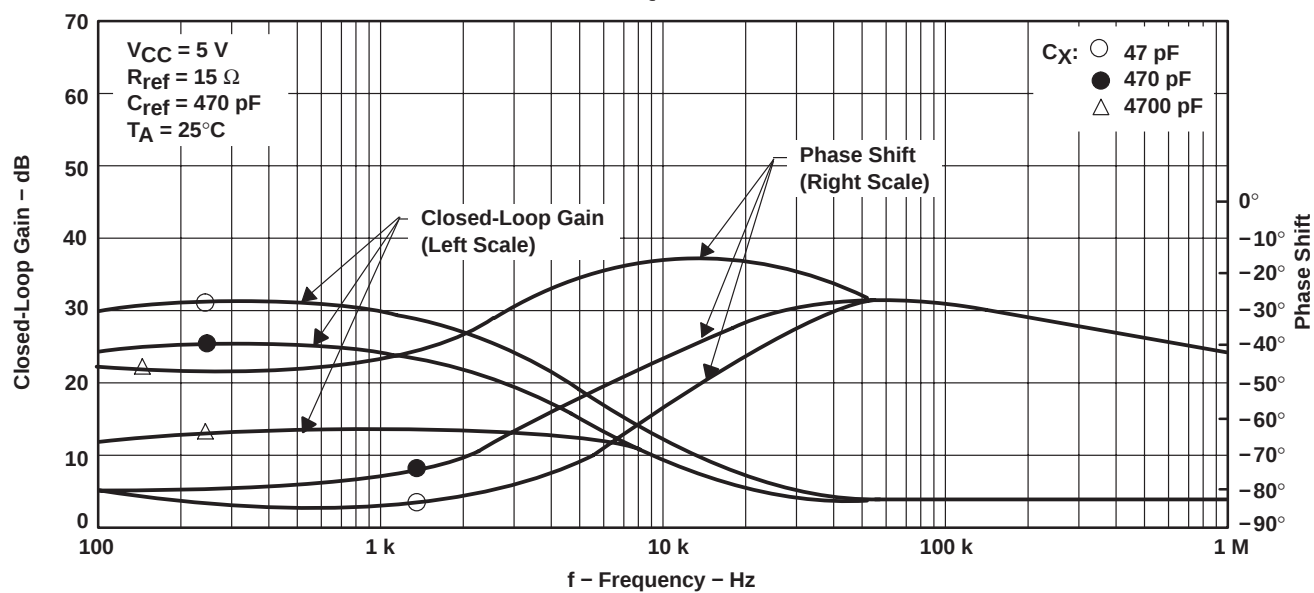
TL1451A-Q1

DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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TYPICAL CHARACTERISTICS

CLOSED-LOOP GAIN AND PHASE SHIFT vs FREQUENCY

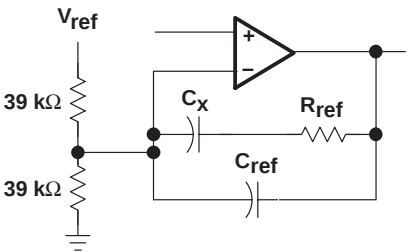
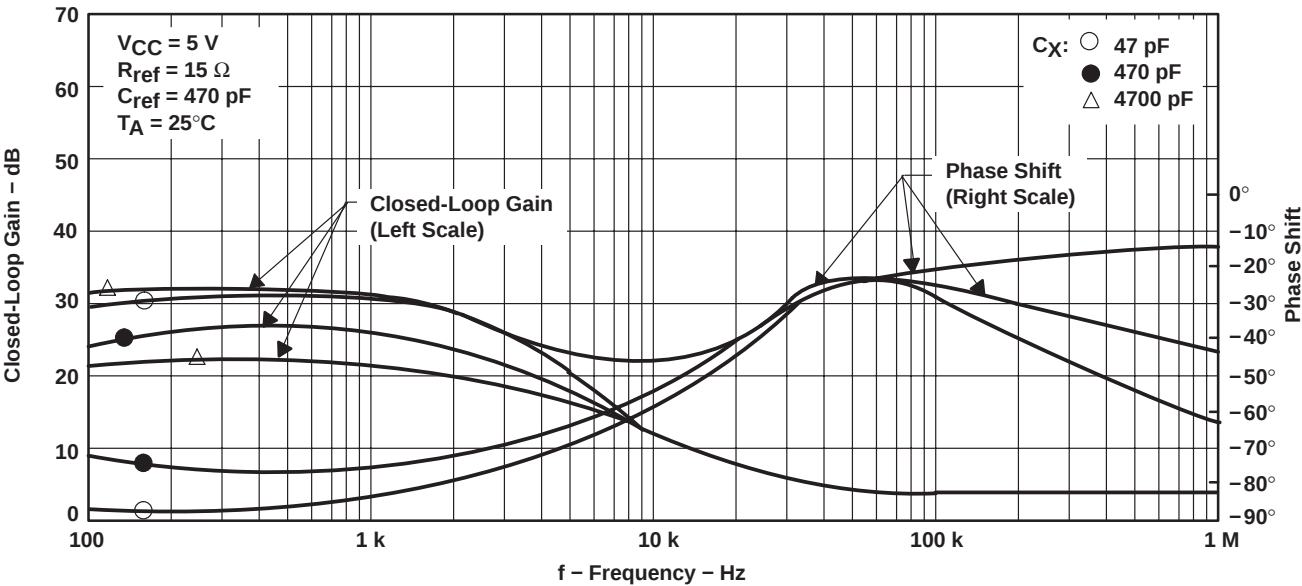


Test Circuit

Figure 19

TYPICAL CHARACTERISTICS

CLOSED-LOOP GAIN AND PHASE SHIFT
VS
FREQUENCY



Test Circuit

Figure 20

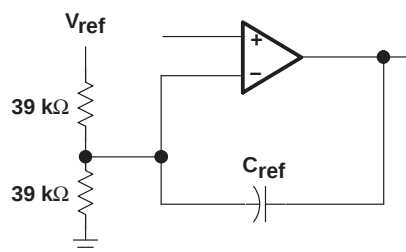
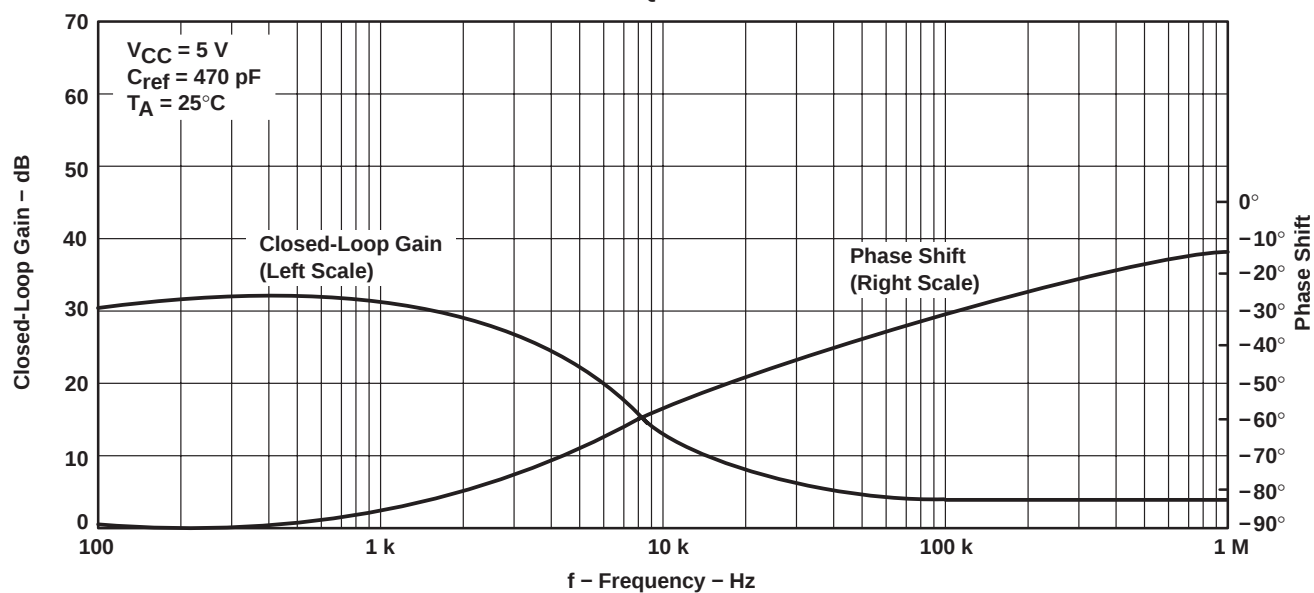
TL1451A-Q1

DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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TYPICAL CHARACTERISTICS

CLOSED-LOOP GAIN AND PHASE SHIFT vs FREQUENCY



Test Circuit

Figure 21

TYPICAL CHARACTERISTICS

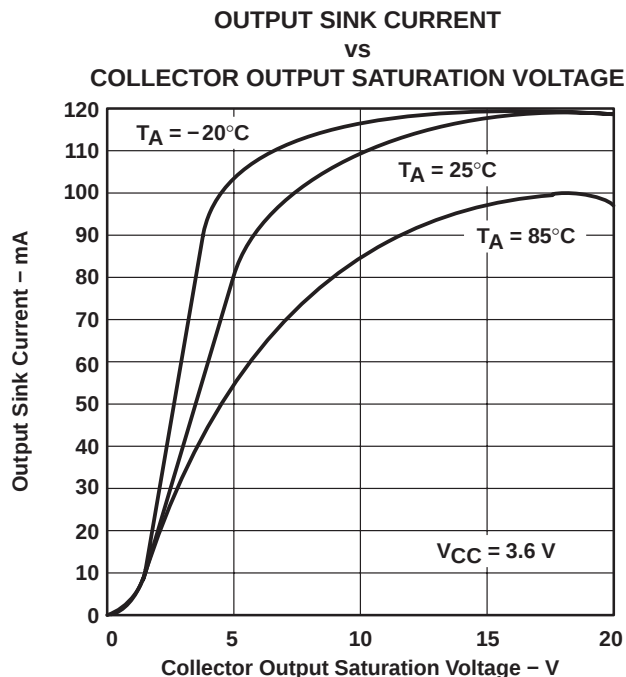


Figure 22

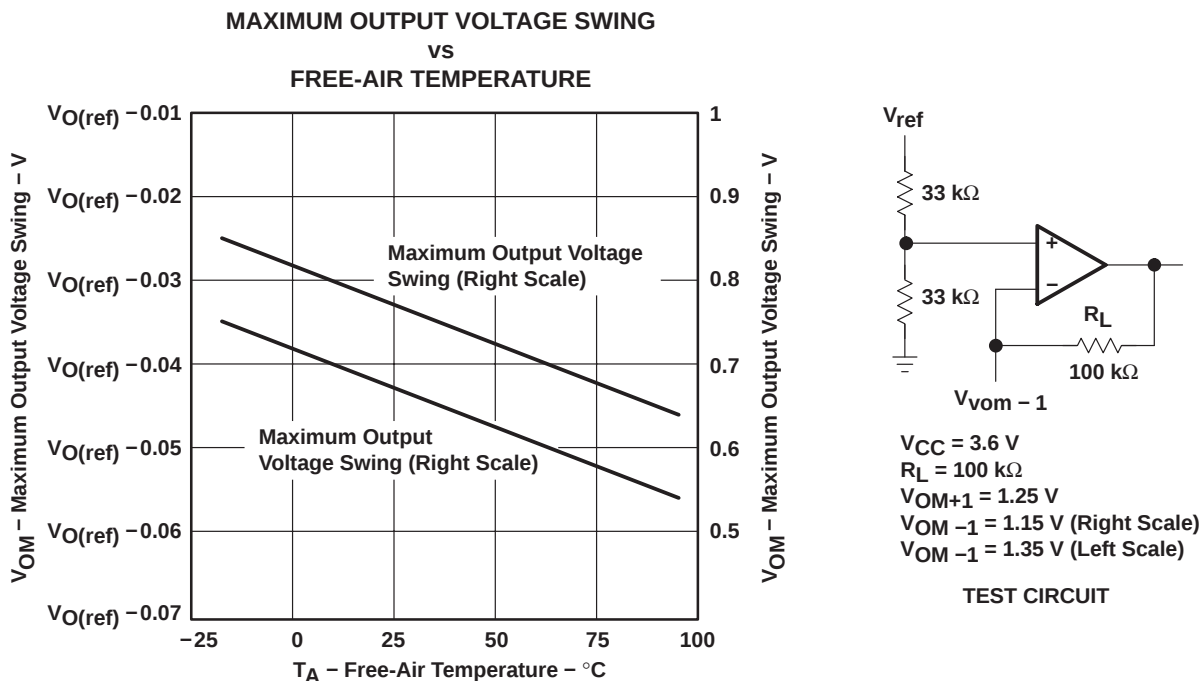


Figure 23

TL1451A-Q1

DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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TYPICAL CHARACTERISTICS

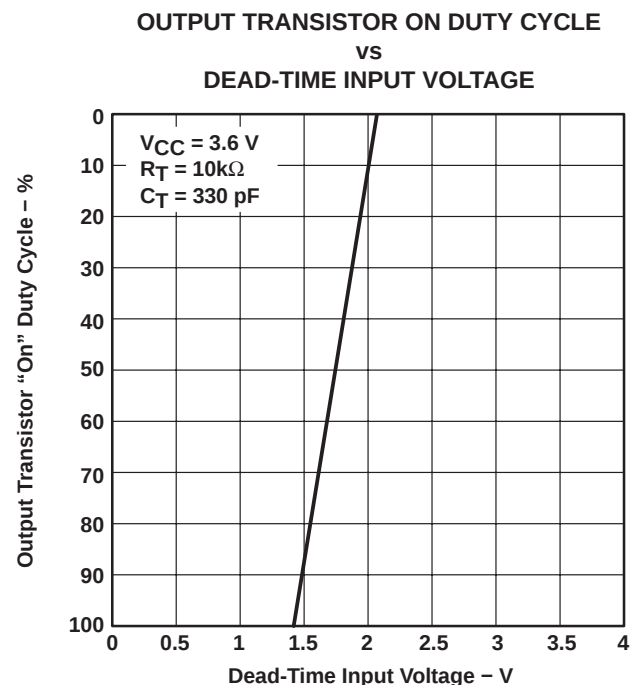


Figure 24

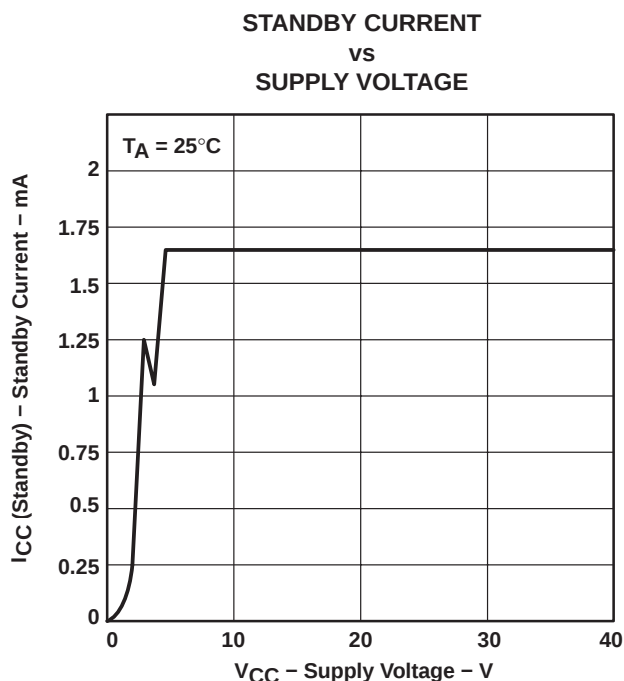


Figure 25

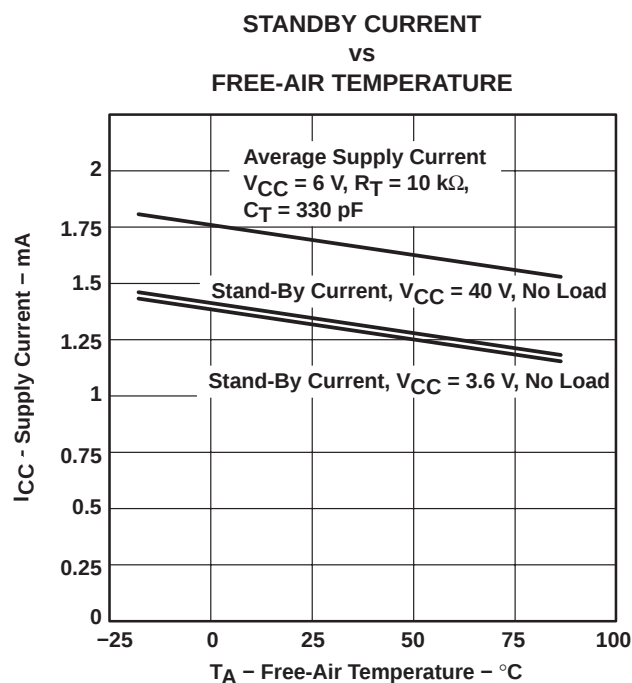


Figure 26

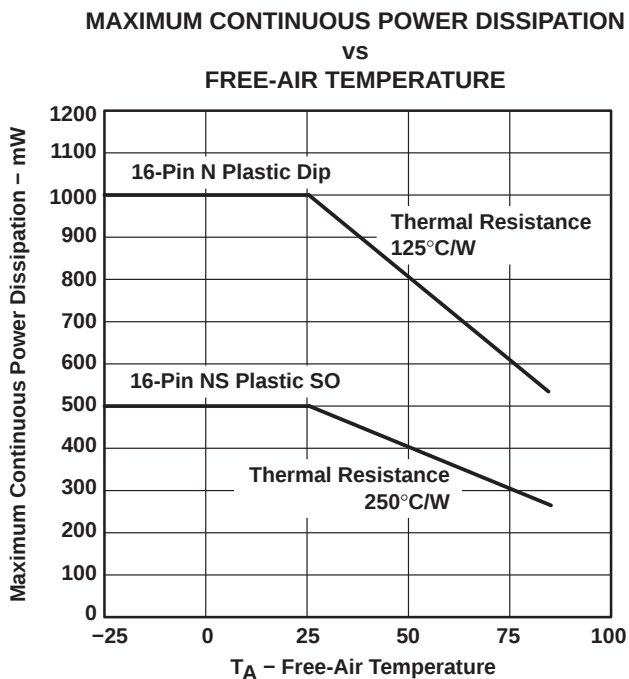
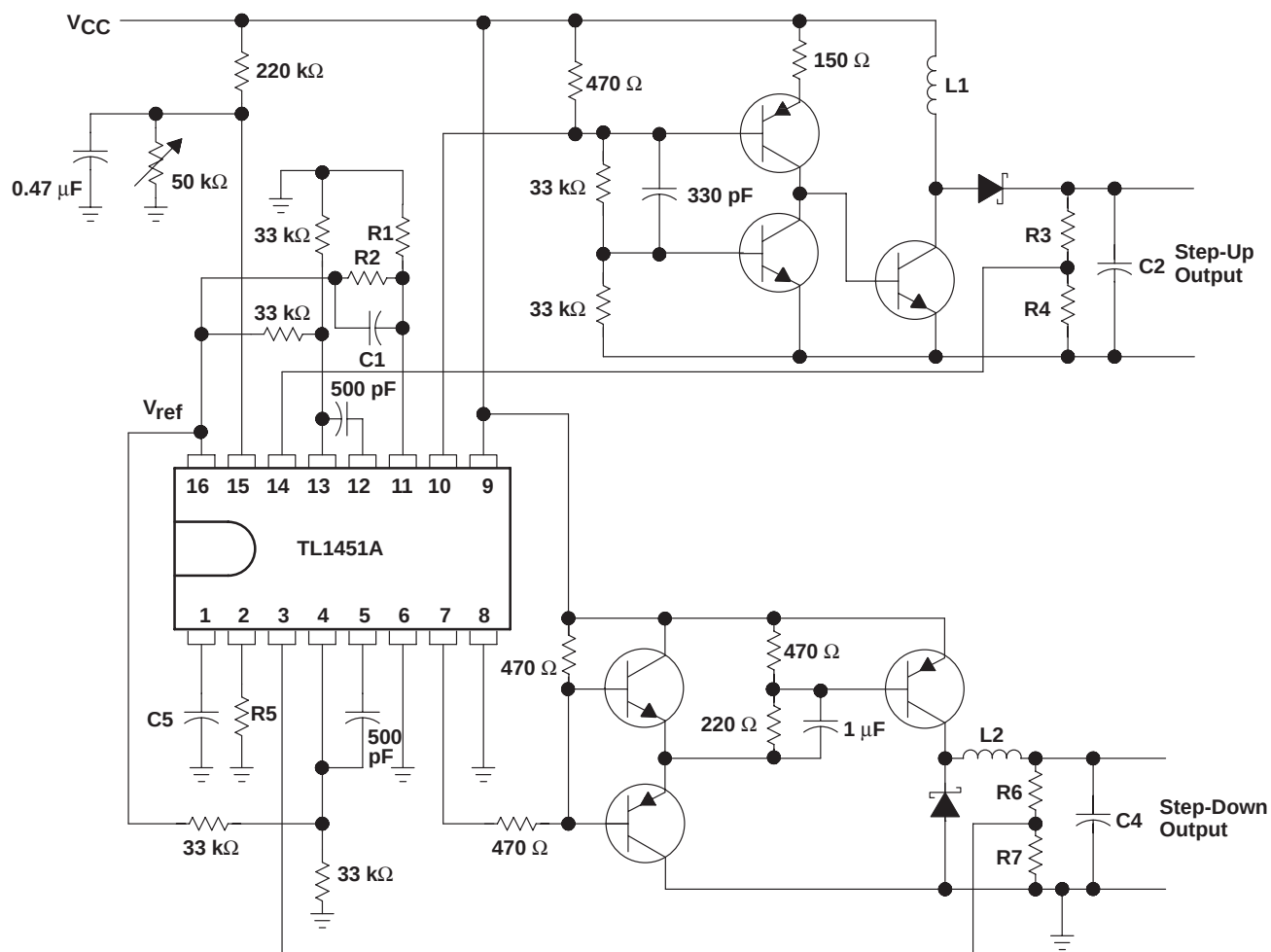


Figure 27

APPLICATION INFORMATION



NOTE A: Values for R1 through R7, C1 through C4, and L1 and L2 depend upon individual application.

Figure 28. High-Speed Dual Switching Regulator

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package Pins	Package qty Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
TL1451AQPWRG4Q1	Active	Production	TSSOP (PW) 16	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	1451AQ
TL1451AQPWRG4Q1.A	Active	Production	TSSOP (PW) 16	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	1451AQ
TL1451AQPWRQ1	Active	Production	TSSOP (PW) 16	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	1451AQ
TL1451AQPWRQ1.A	Active	Production	TSSOP (PW) 16	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	1451AQ

⁽¹⁾ **Status:** For more details on status, see our [product life cycle](#).

⁽²⁾ **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

⁽³⁾ **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

⁽⁴⁾ **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

⁽⁵⁾ **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

⁽⁶⁾ **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "-" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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OTHER QUALIFIED VERSIONS OF TL1451A-Q1 :

- Catalog : [TL1451A](#)
- Enhanced Product : [TL1451A-EP](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product
- Enhanced Product - Supports Defense, Aerospace and Medical Applications

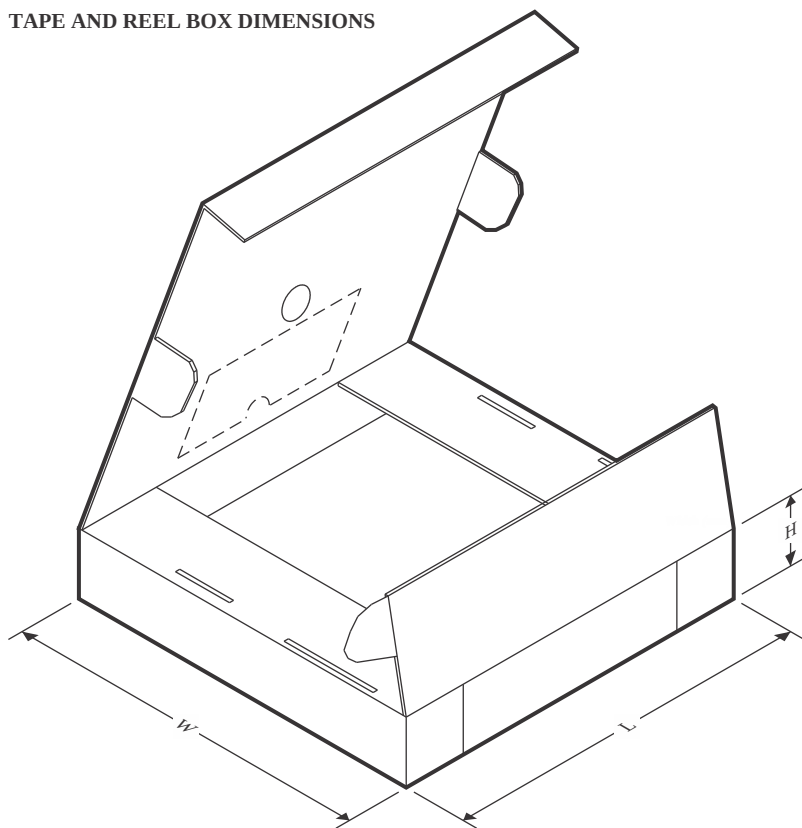
TAPE AND REEL INFORMATION



*All dimensions are nominal

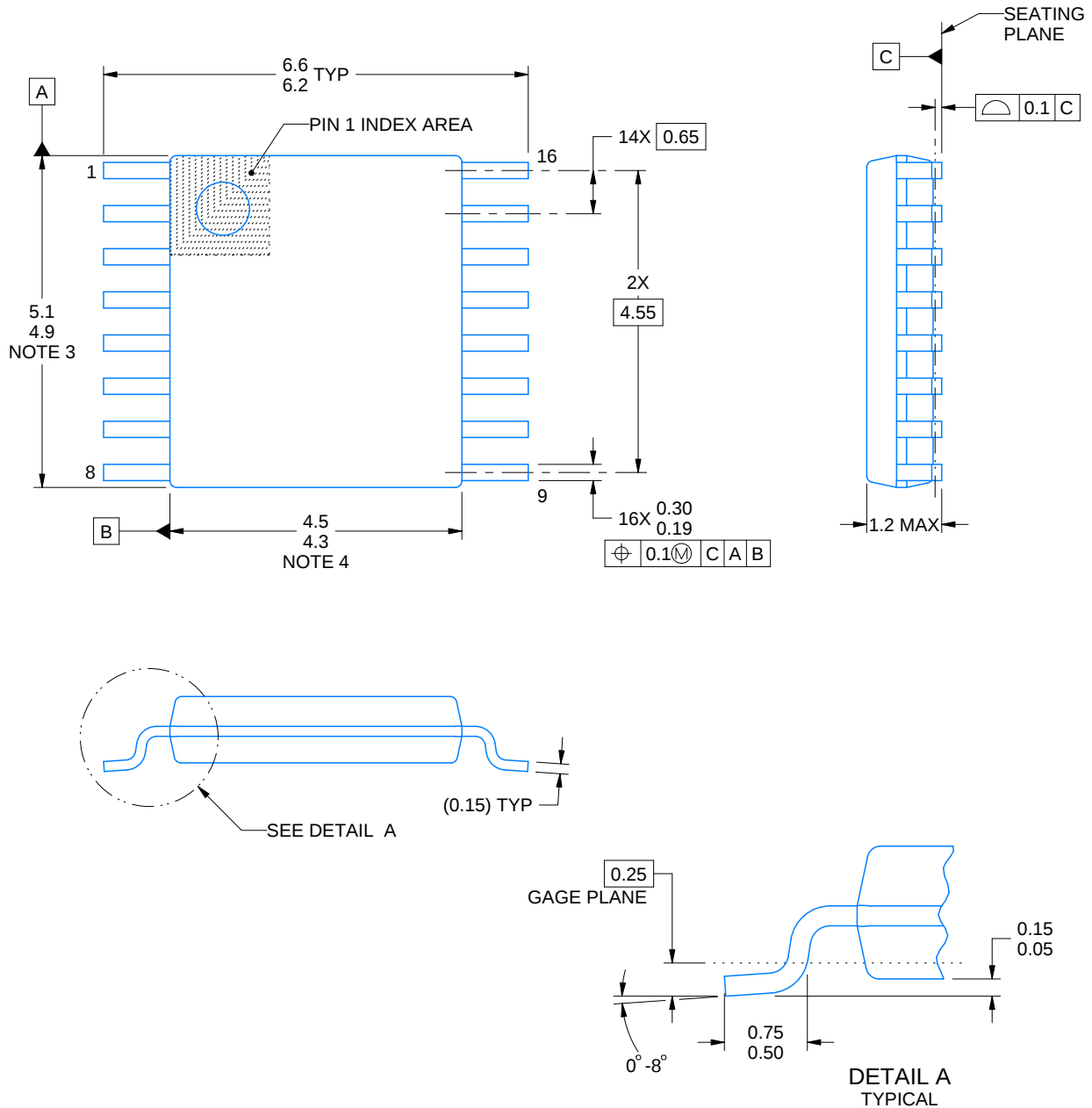
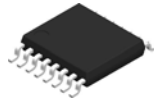
Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TL1451AQPWRG4Q1	TSSOP	PW	16	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1
TL1451AQPWRQ1	TSSOP	PW	16	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TL1451AQPWRG4Q1	TSSOP	PW	16	2000	356.0	356.0	35.0
TL1451AQPWRQ1	TSSOP	PW	16	2000	356.0	356.0	35.0



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NOTES:

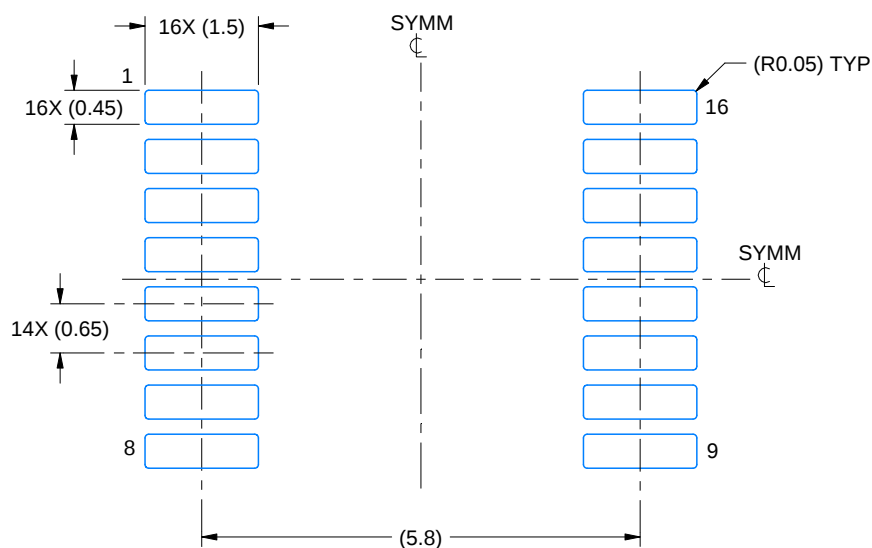
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-153.

EXAMPLE BOARD LAYOUT

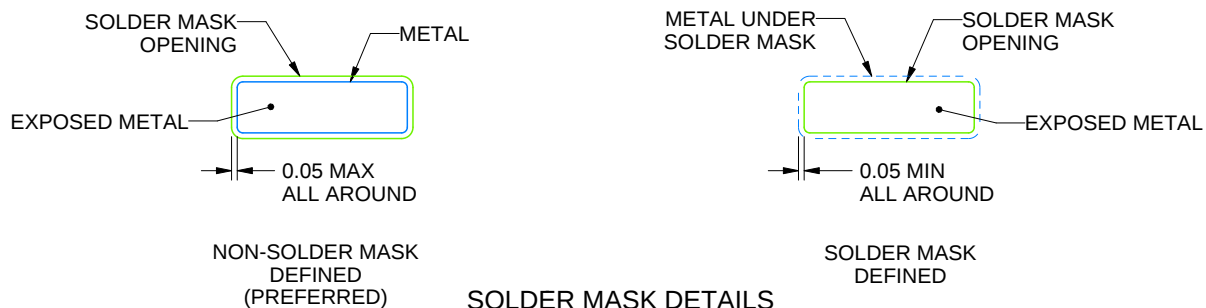
PW0016A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 10X



4220204/A 02/2017

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

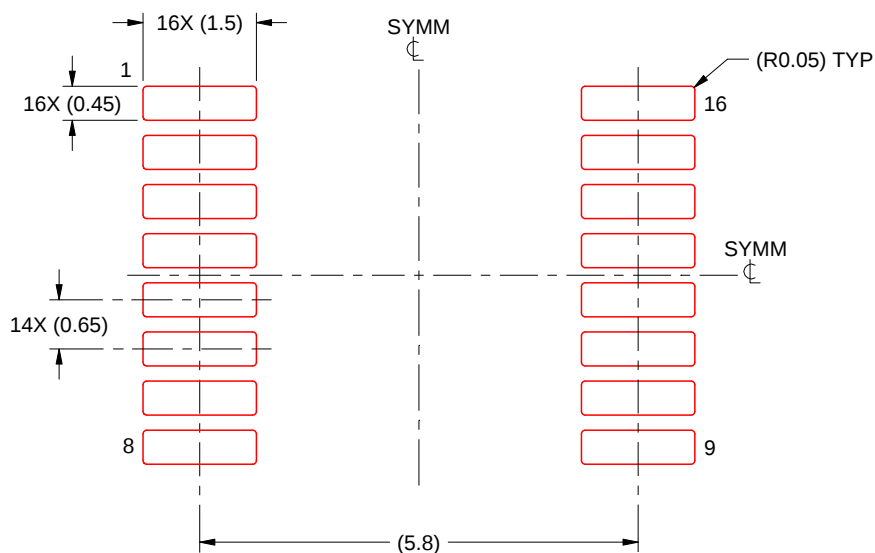
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

PW0016A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE: 10X

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NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

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