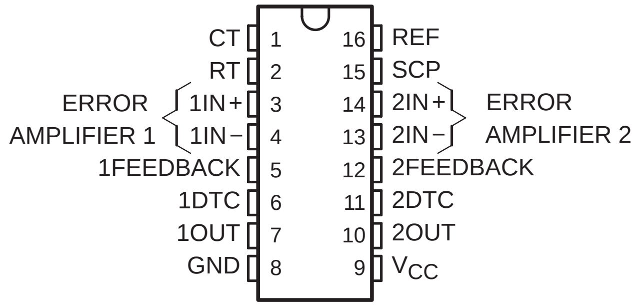
- **Qualified for Automotive Applications**
- **Complete PWM Power Control Circuitry**
- **Completely Synchronized Operation**
- **Internal Undervoltage Lockout Protection**
- **Wide Supply Voltage Range**
- **Internal Short-Circuit Protection**
- **Oscillator Frequency . . . 500 kHz Max**
- **Variable 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.

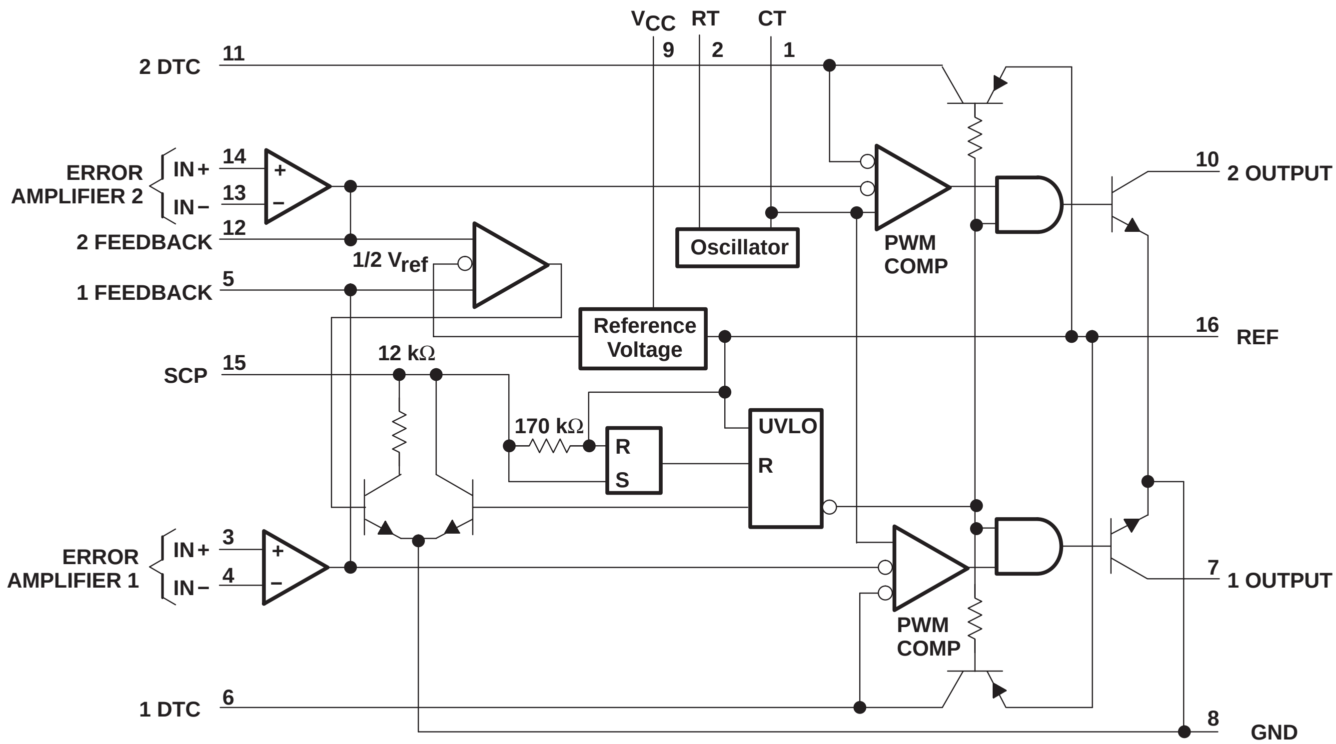
The TL1451A is characterized for operation from −40°C to 125°C.

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.

functional block diagram



COMPONENT COUNT

Resistors	65
Capacitors	8
Transistors	105
JFETs	18

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	$T_A \leq 25°C$ POWER RATING	DERATING FACTOR ABOVE $T_A = 25°C$	$T_A = 70°C$ POWER RATING	$T_A = 85°C$ POWER RATING	$T_A = 125°C$ 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

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

reference section

PARAMETER	TEST CONDITIONS		TL1451AQ MIN	TL1451AQ TYP†	TL1451AQ MAX	UNIT
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°C unless otherwise indicated.
‡ These parameters are not production tested.

undervoltage lockout section

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

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

short-circuit protection control section

PARAMETER	TEST CONDITIONS	TL1451AQ MIN	TL1451AQ TYP†	TL1451AQ MAX	UNIT
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 MIN	TL1451AQ TYP†	TL1451AQ MAX	UNIT
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 MIN	TL1451AQ TYP†	TL1451AQ MAX	UNIT
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.

error-amplifier section

PARAMETER	TEST CONDITIONS		TL1451AQ MIN	TYP†	MAX	UNIT
Input offset voltage	V_O (FEEDBACK) = 1.25 V	T_A = 25°C			±7	mV
		T_A = 125°C			±10	
		T_A = MIN			±12	
Input offset current	V_O (FEEDBACK) = 1.25 V	T_A = 25°C			±100	nA
		T_A = 125°C			±100	
		T_A = MIN			±200	
Input bias current	V_O (FEEDBACK) = 1.25 V	T_A = 25°C		160	500	nA
		T_A = 125°C		100	500	
		T_A = MIN		142	700	
Common-mode input voltage range	V_{CC} = 3.6 V to 40 V		1.05 to 1.45			V
Open-loop voltage amplification	R_F = 200 kΩ	T_A = 25°C	70	80		dB
		T_A = 125°C	70	80		
		T_A = 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 V, V_O = 1.25 V	T_A = 25°C	0.5	1.6		mA
		T_A = 125°C	0.4	1.8		
		T_A = MIN	0.3	1.7		
Output (source) current (FEEDBACK)	V_{ID} = 0.1 V, V_O = 1.25 V	T_A = 25°C	−45	−70		μA
		T_A = 125°C	−25	−50		
		T_A = MIN	−15	−70		

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

output section

PARAMETER	TEST CONDITIONS	TL1451AQ MIN	TYP†	MAX	UNIT
Collector off-state current	V_O = 50 V			10	μA
Output saturation voltage	T_A = 25°C		1.2	2	V
	T_A = 125°C		1.6	2.4	
	T_A = MIN		1.36	2.2	
Short-circuit output current	V_O = 6 V		90		mA

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

pwm comparator section

PARAMETER	TEST CONDITIONS	TL1451AQ MIN	TYP†	MAX	UNIT
Input threshold voltage at f = 10 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°C unless otherwise indicated.
‡ These parameters are not production tested.

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 kΩ		1.7	2.4	mA

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

PARAMETER MEASUREMENT INFORMATION

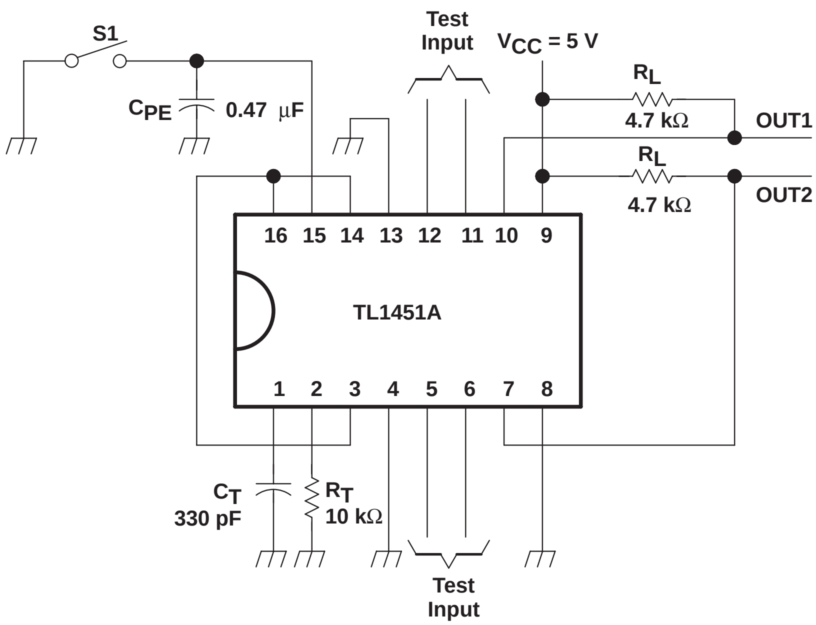
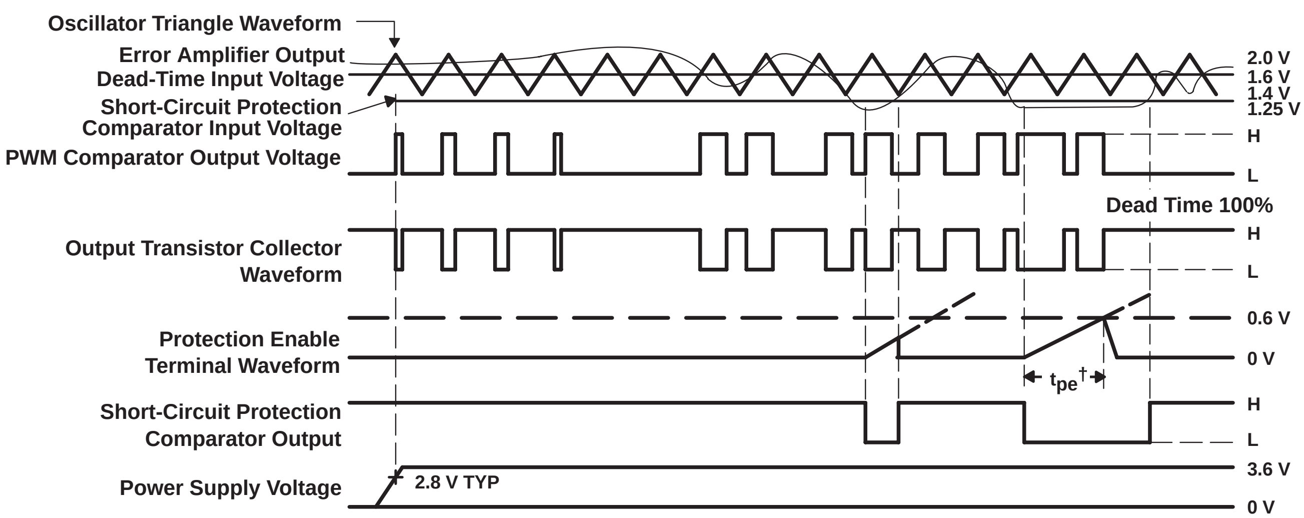


Figure 1. Test Circuit



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

Figure 2. TL1451A Timing Diagram

TYPICAL CHARACTERISTICS

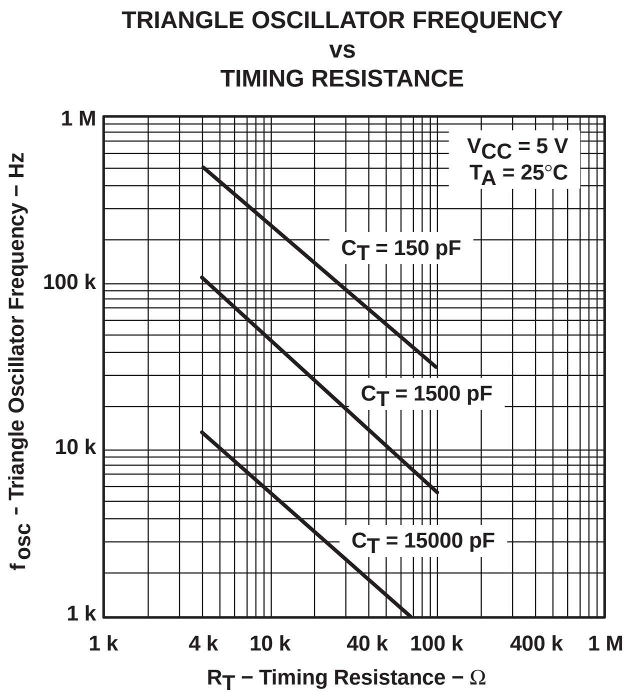


Figure 3

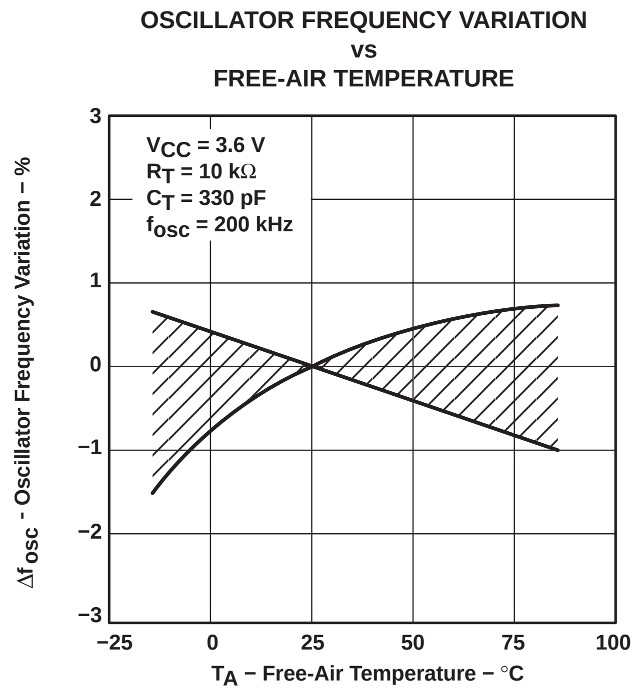


Figure 4

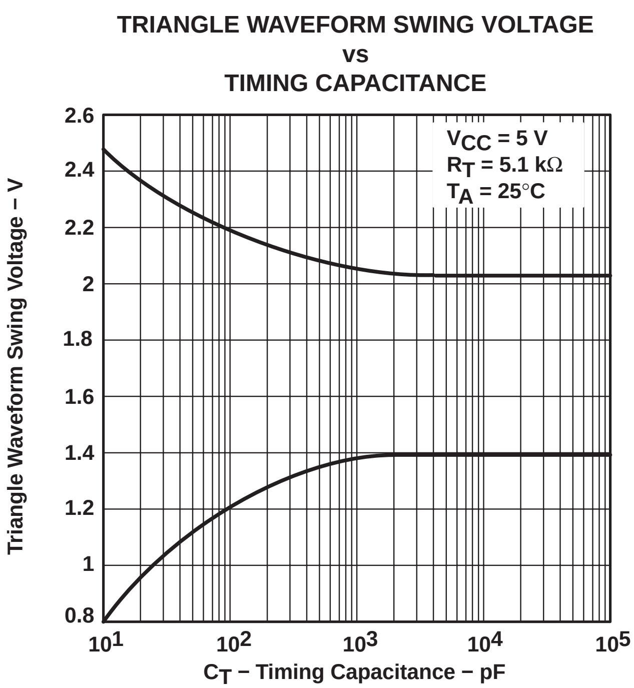


Figure 5

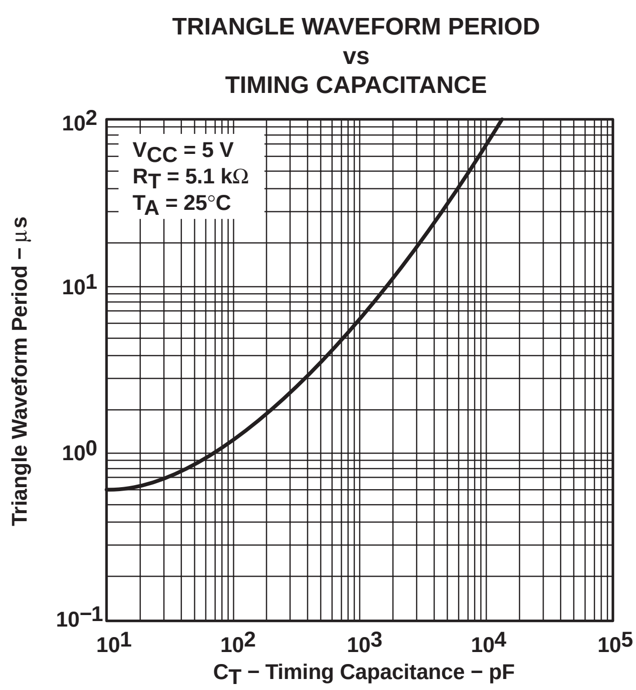


Figure 6

TYPICAL CHARACTERISTICS

REFERENCE OUTPUT VOLTAGE VARIATION
vs
FREE-AIR TEMPERATURE

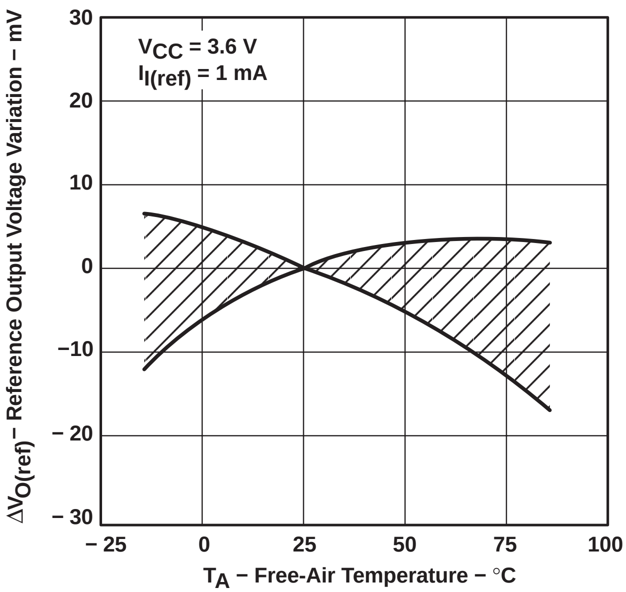


Figure 7

REFERENCE OUTPUT VOLTAGE VARIATION
vs
FREE-AIR TEMPERATURE

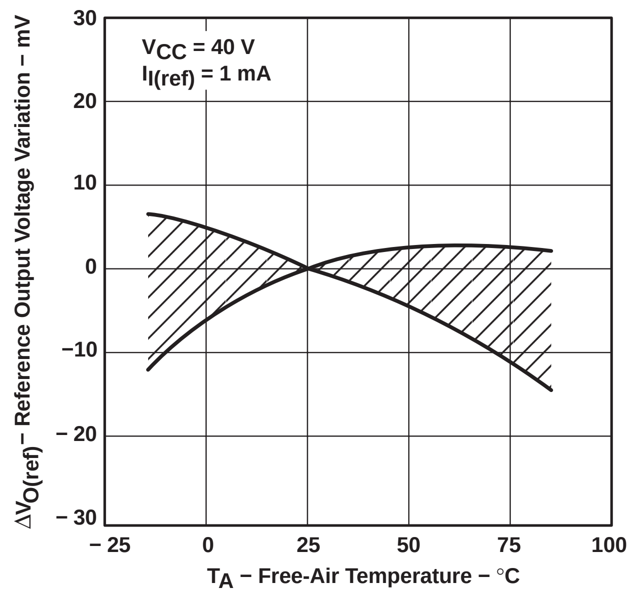


Figure 8

REFERENCE OUTPUT VOLTAGE
vs
SUPPLY VOLTAGE

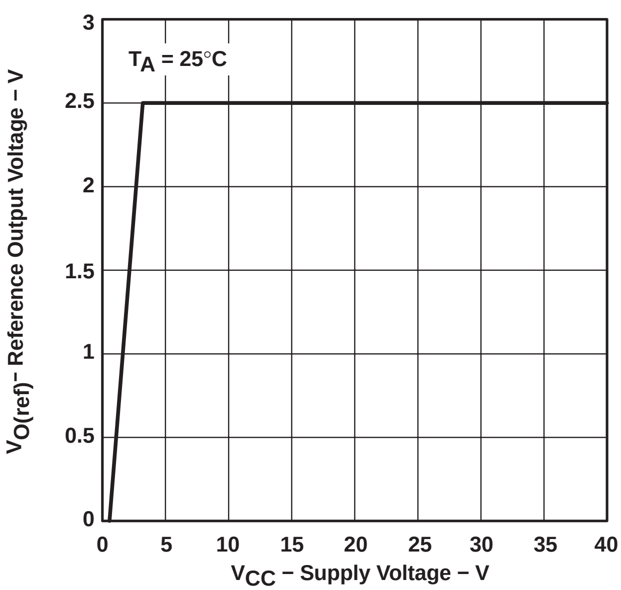


Figure 9

DROPOUT VOLTAGE VARIATION
vs
FREE-TEMPERATURE

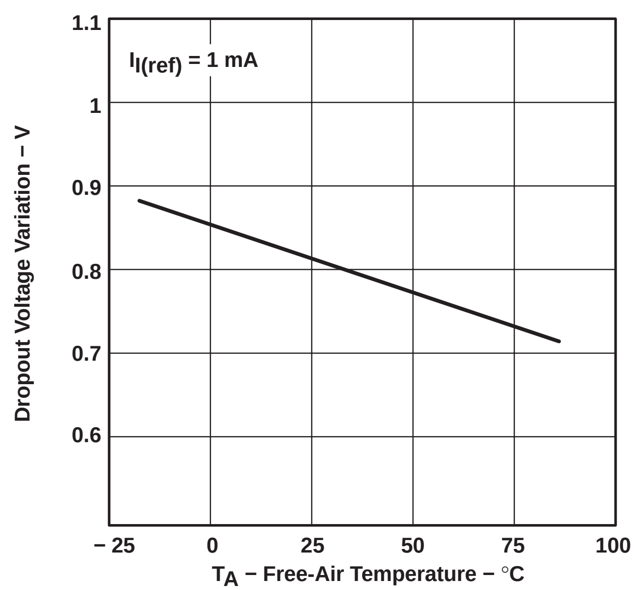


Figure 10

TYPICAL CHARACTERISTICS

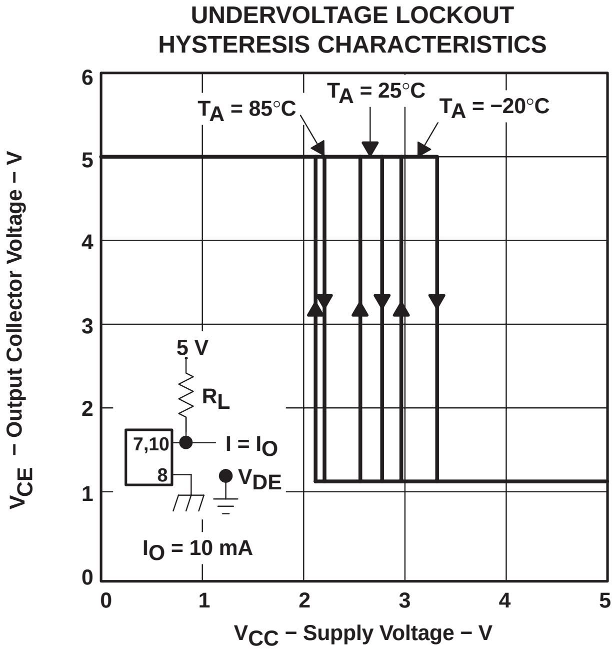


Figure 11

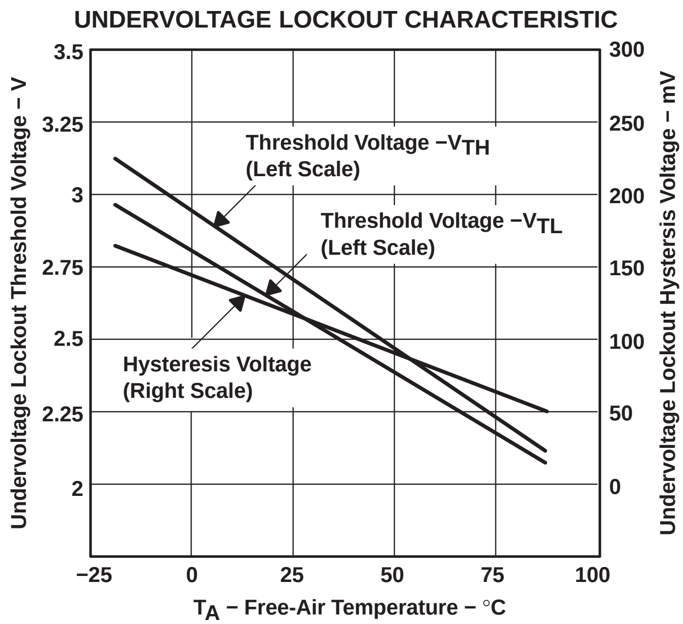


Figure 12

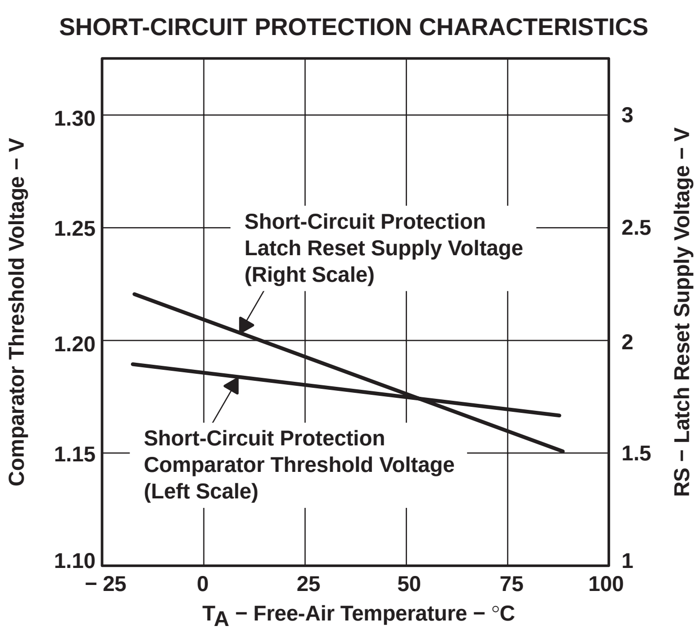
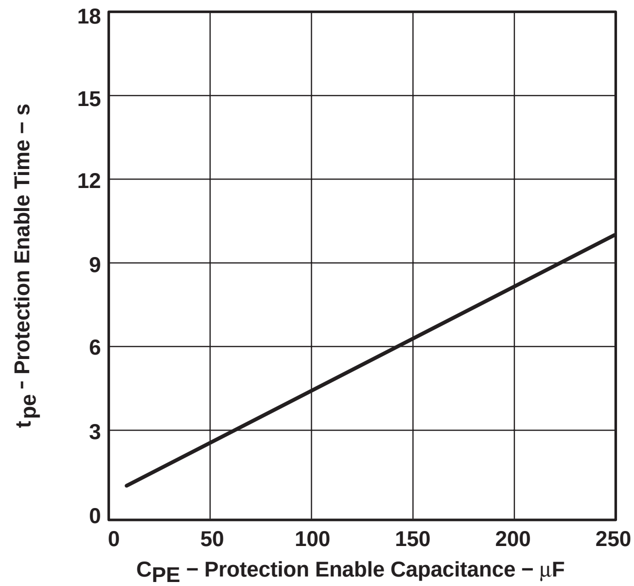


Figure 13

TYPICAL CHARACTERISTICS

PROTECTION ENABLE TIME vs PROTECTION ENABLE CAPACITANCE



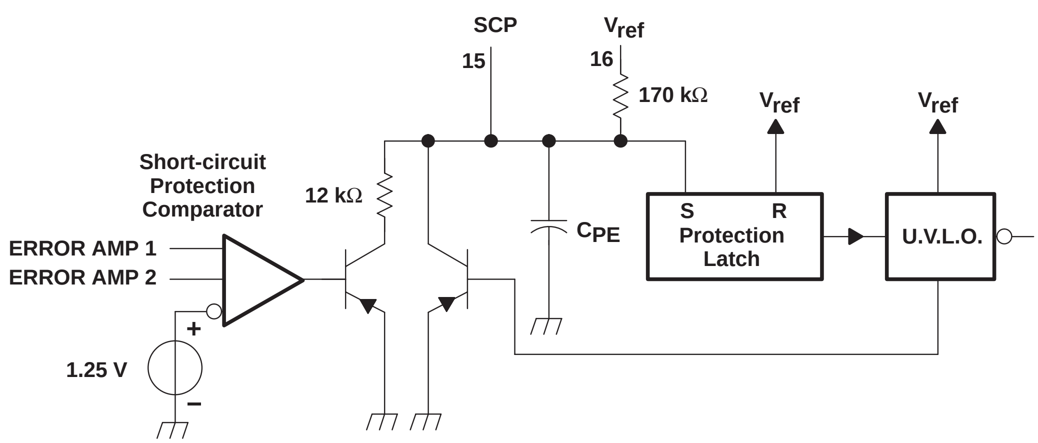


Figure 14

TYPICAL CHARACTERISTICS

ERROR AMP MAXIMUM OUTPUT VOLTAGE SWING
vs
FREQUENCY

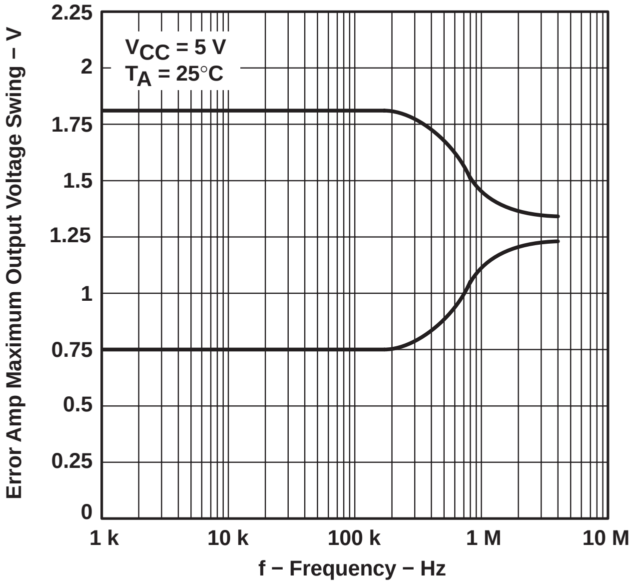


Figure 15

OPEN-LOOP VOLTAGE AMPLIFICATION
vs
FREQUENCY

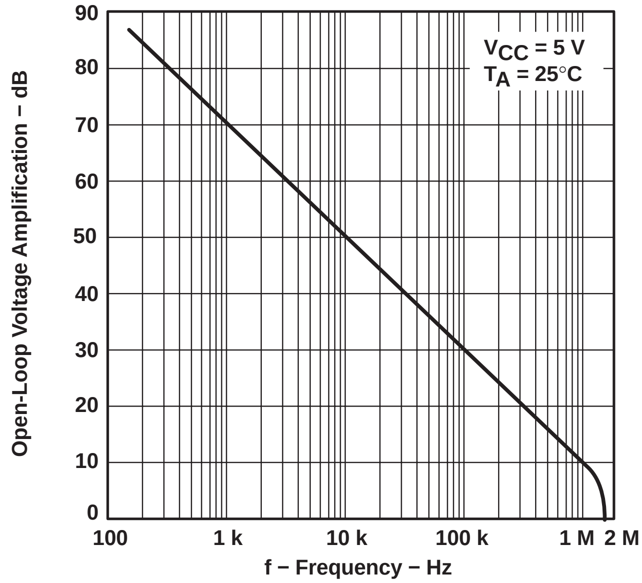


Figure 16

GAIN (AMPLIFIER IN
UNITY-GAIN CONFIGURATION)
vs
FREQUENCY

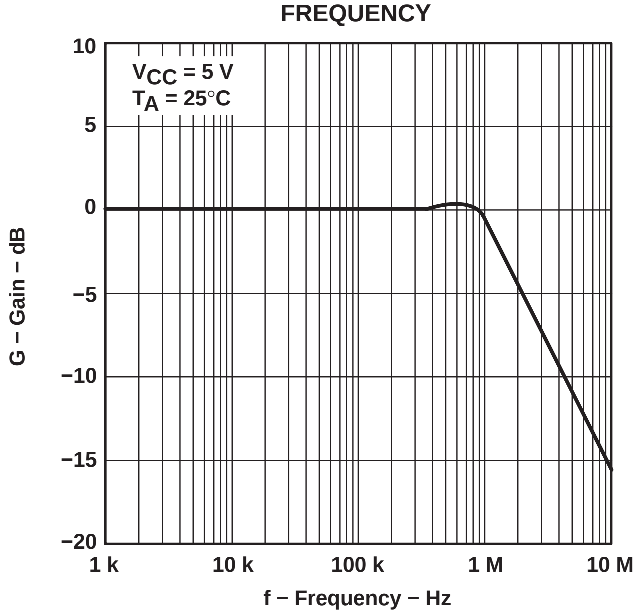
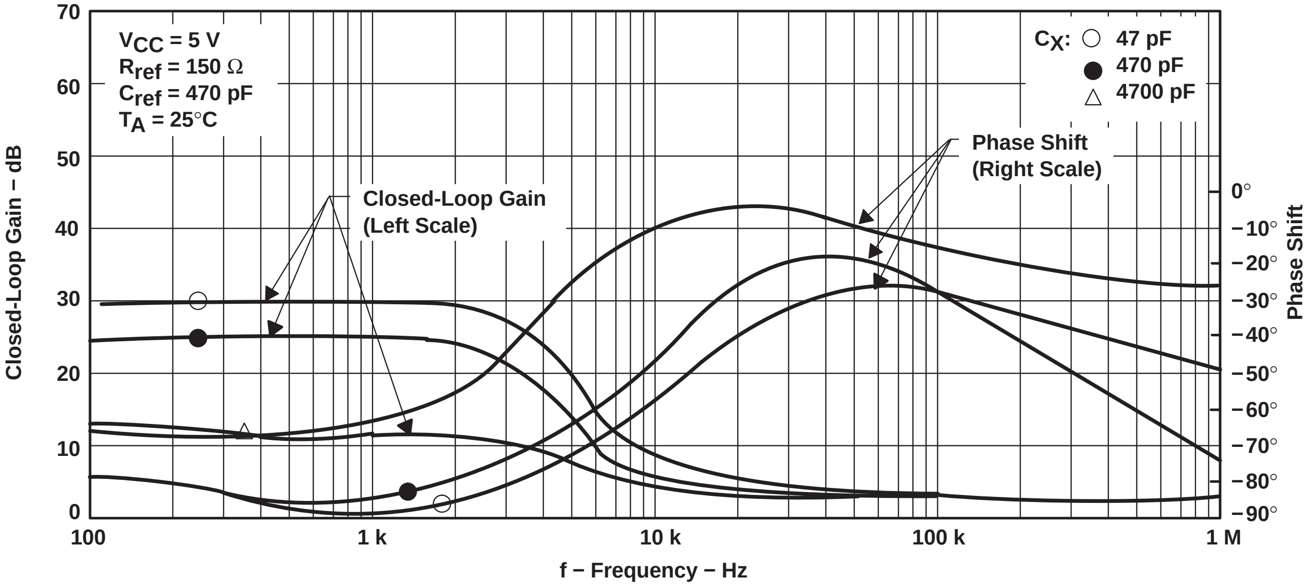
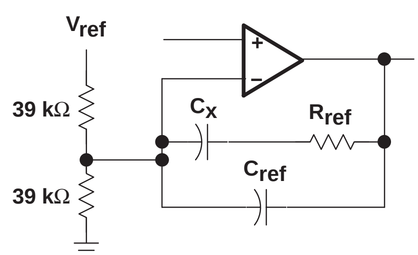


Figure 17

TYPICAL CHARACTERISTICS

CLOSED-LOOP GAIN AND PHASE SHIFT vs FREQUENCY



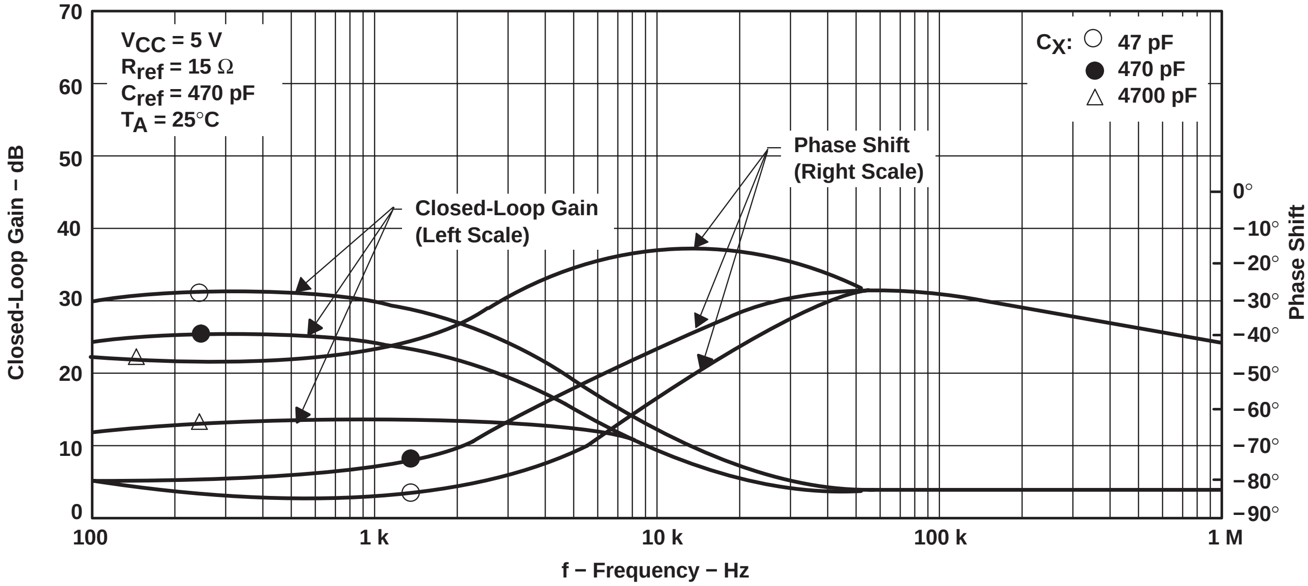


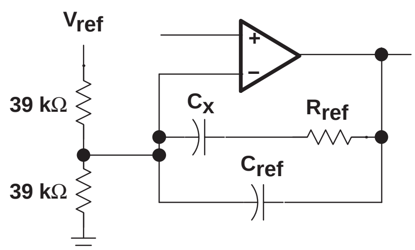
Test Circuit

Figure 18

TYPICAL CHARACTERISTICS

CLOSED-LOOP GAIN AND PHASE SHIFT
vs
FREQUENCY



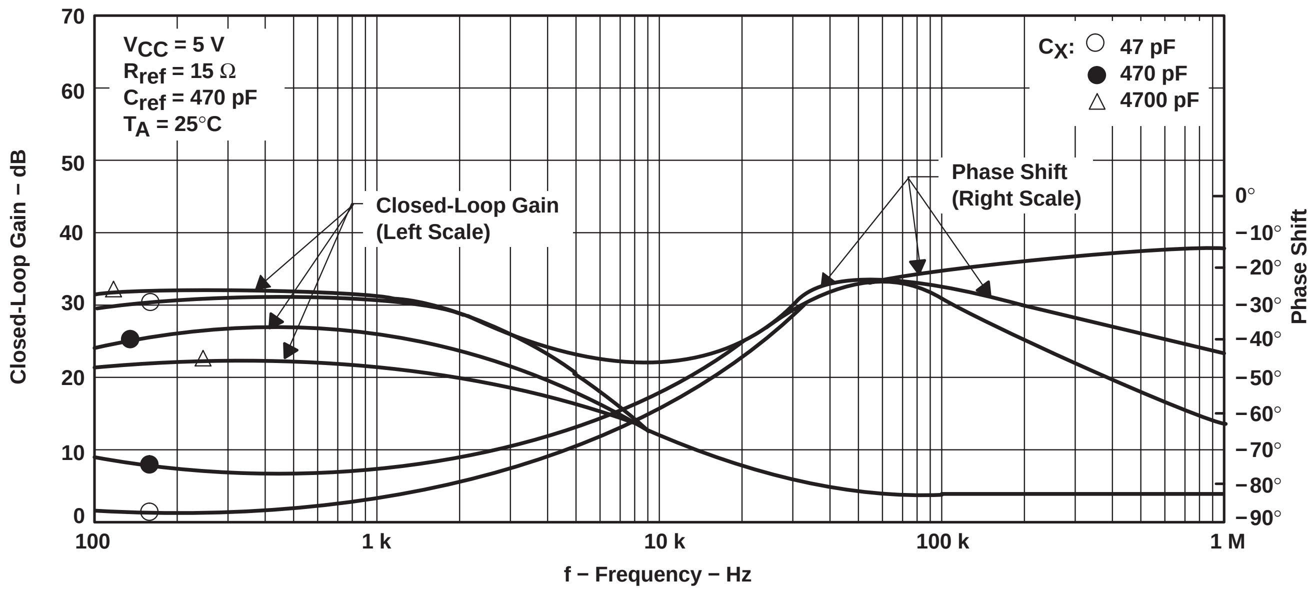


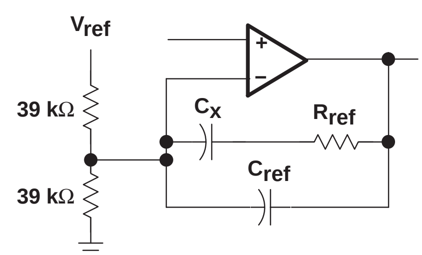
Test Circuit

Figure 19

TYPICAL CHARACTERISTICS

CLOSED-LOOP GAIN AND PHASE SHIFT
vs
FREQUENCY



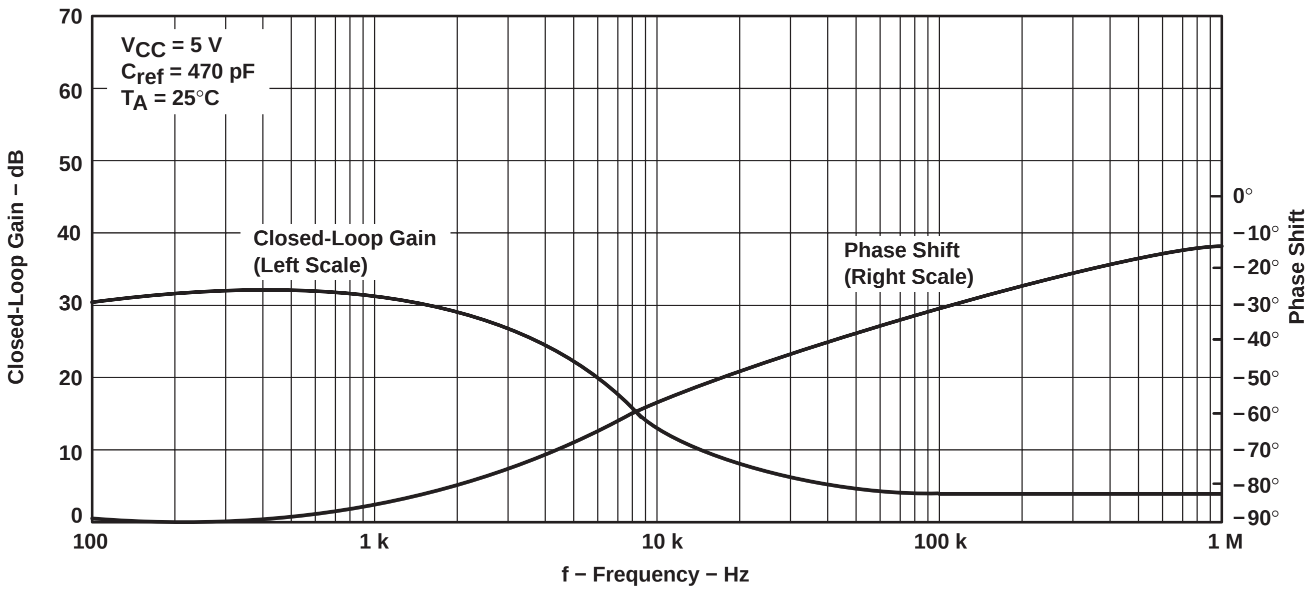


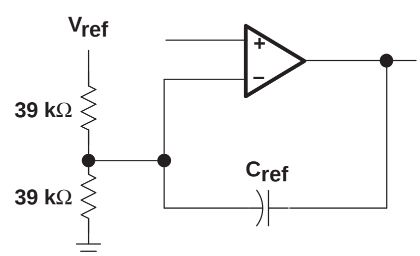
Test Circuit

Figure 20

TYPICAL CHARACTERISTICS

CLOSED-LOOP GAIN AND PHASE SHIFT
vs
FREQUENCY





Test Circuit

Figure 21

TYPICAL CHARACTERISTICS

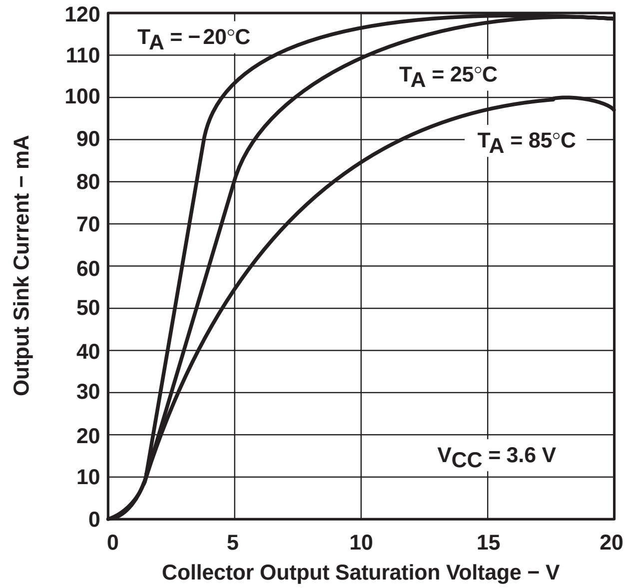


Figure 22

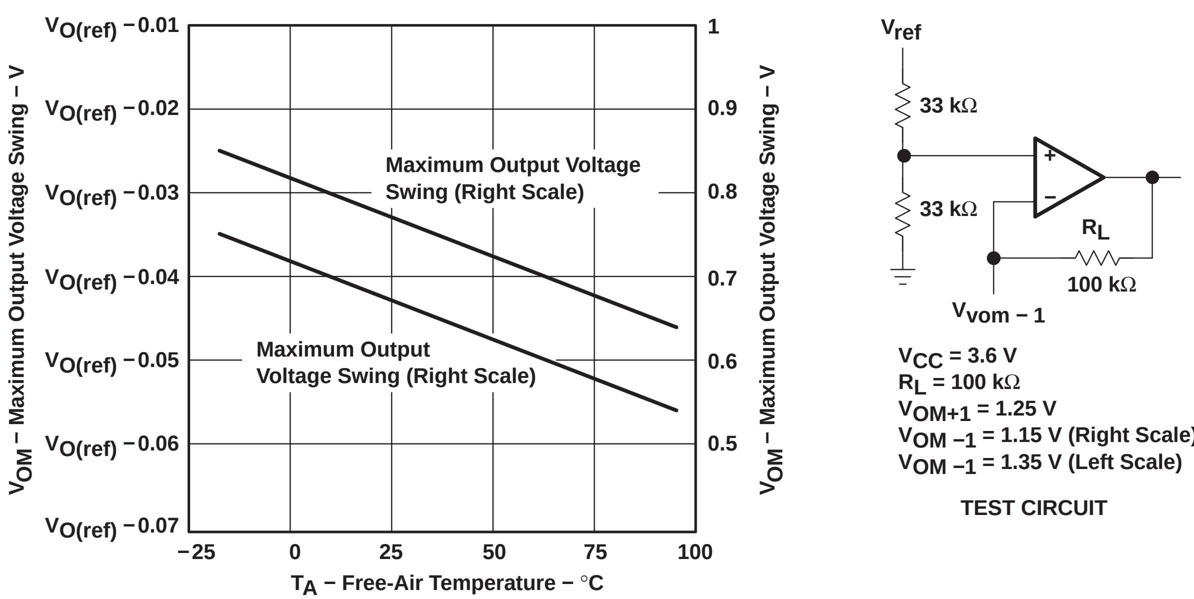


Figure 23

TYPICAL CHARACTERISTICS

OUTPUT TRANSISTOR ON DUTY CYCLE vs DEAD-TIME INPUT VOLTAGE

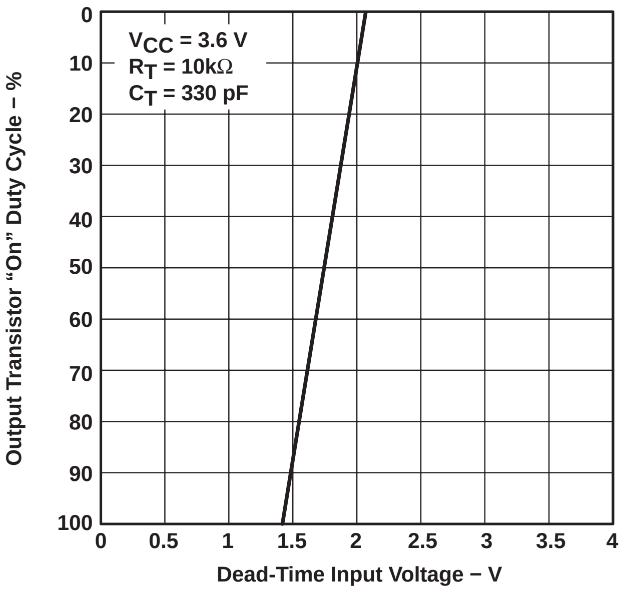


Figure 24

STANDBY CURRENT vs SUPPLY VOLTAGE

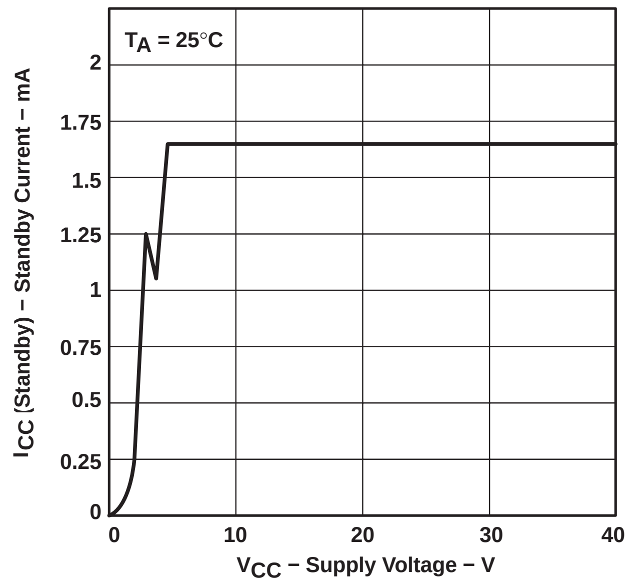


Figure 25

STANDBY CURRENT vs FREE-AIR TEMPERATURE

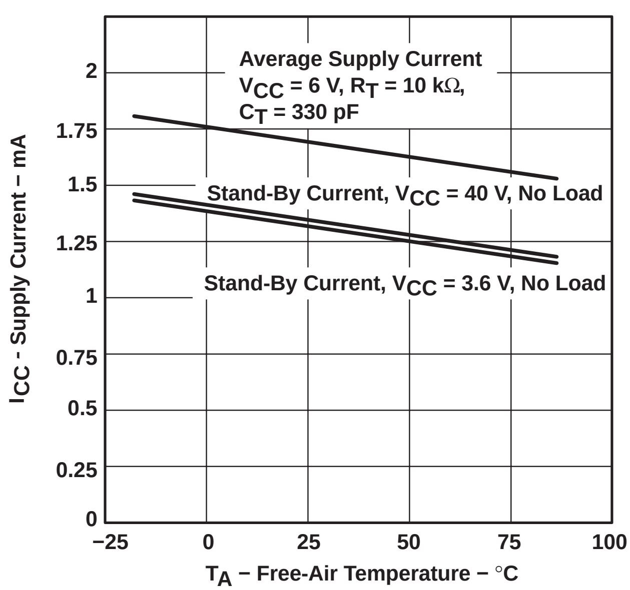


Figure 26

MAXIMUM CONTINUOUS POWER DISSIPATION vs FREE-AIR TEMPERATURE

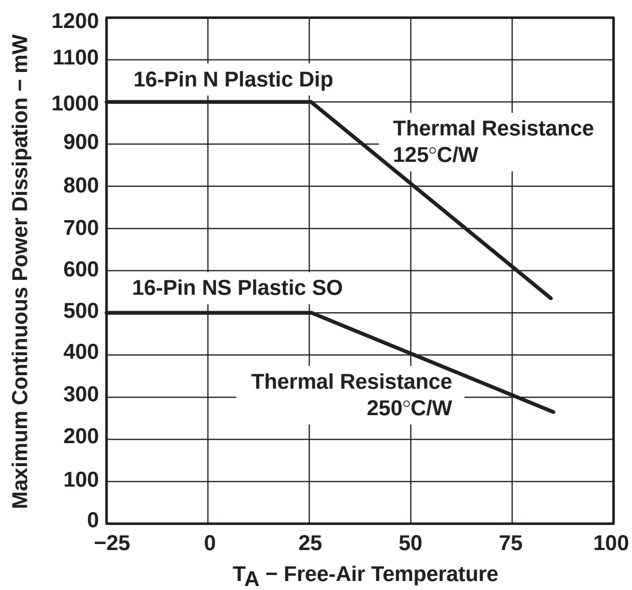
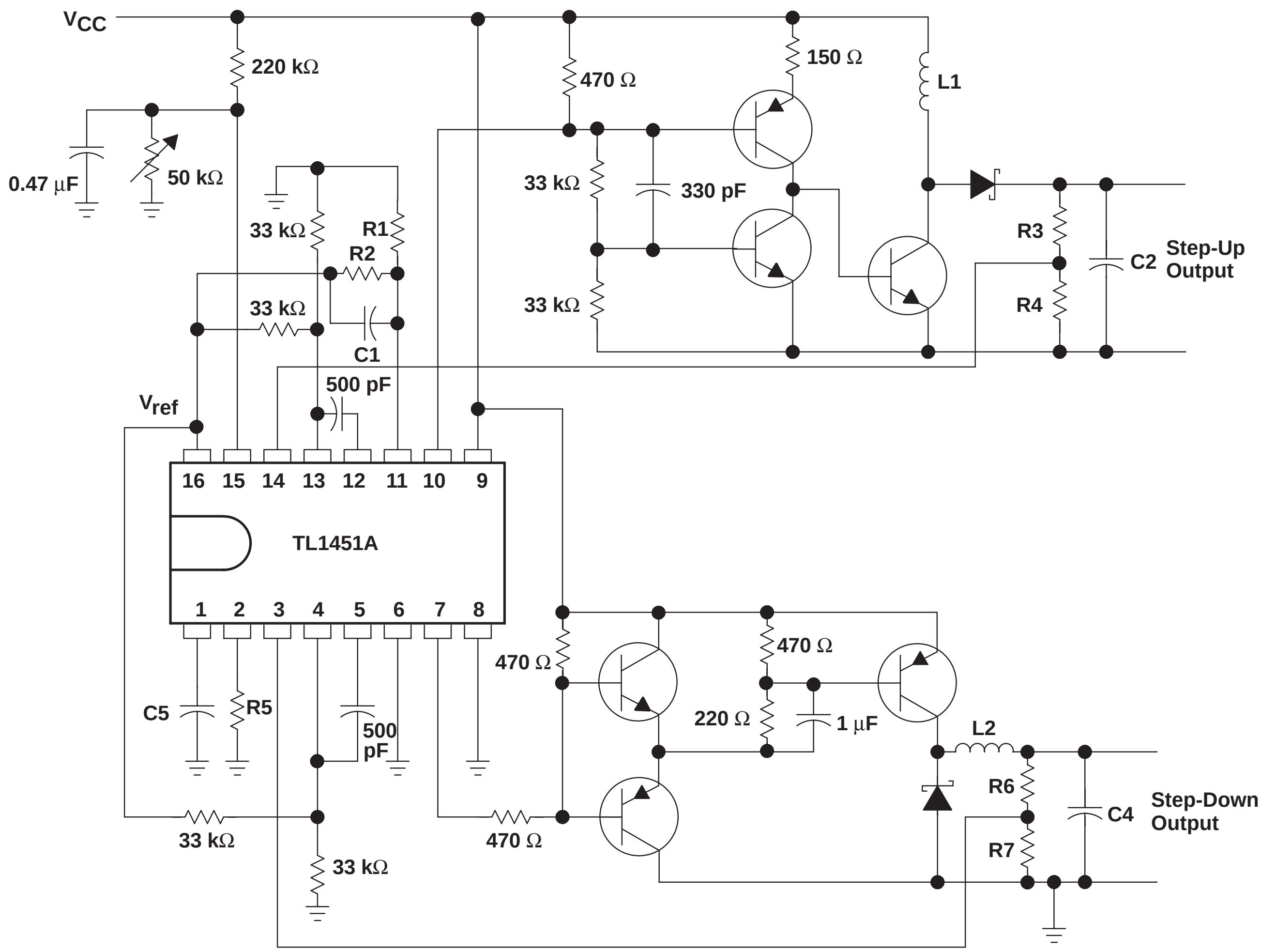


Figure 27

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 Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TL1451AQPWRG4Q1	ACTIVE	TSSOP	PW	16	2000	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	-40 to 125	1451AQ	Samples
TL1451AQPWRQ1	ACTIVE	TSSOP	PW	16	2000	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	-40 to 125	1451AQ	Samples

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

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

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

OTHER QUALIFIED VERSIONS OF TL1451A-Q1 :

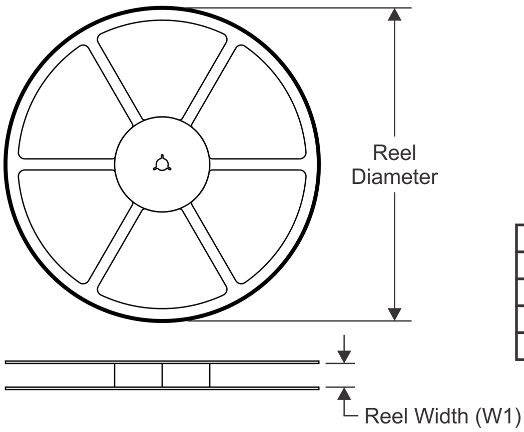
- Catalog: TL1451A
- Enhanced Product: TL1451A-EP

NOTE: Qualified Version Definitions:

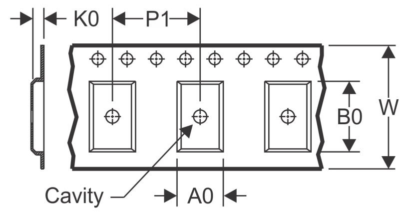
- Catalog - TI's standard catalog product
- Enhanced Product - Supports Defense, Aerospace and Medical Applications

TAPE AND REEL INFORMATION

REEL DIMENSIONS

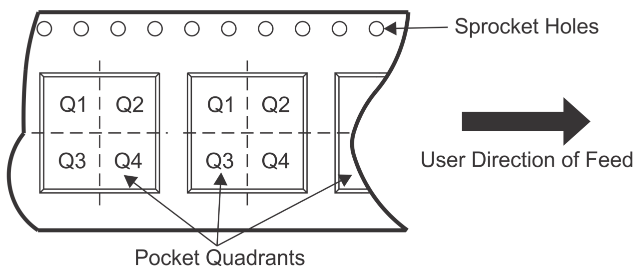


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

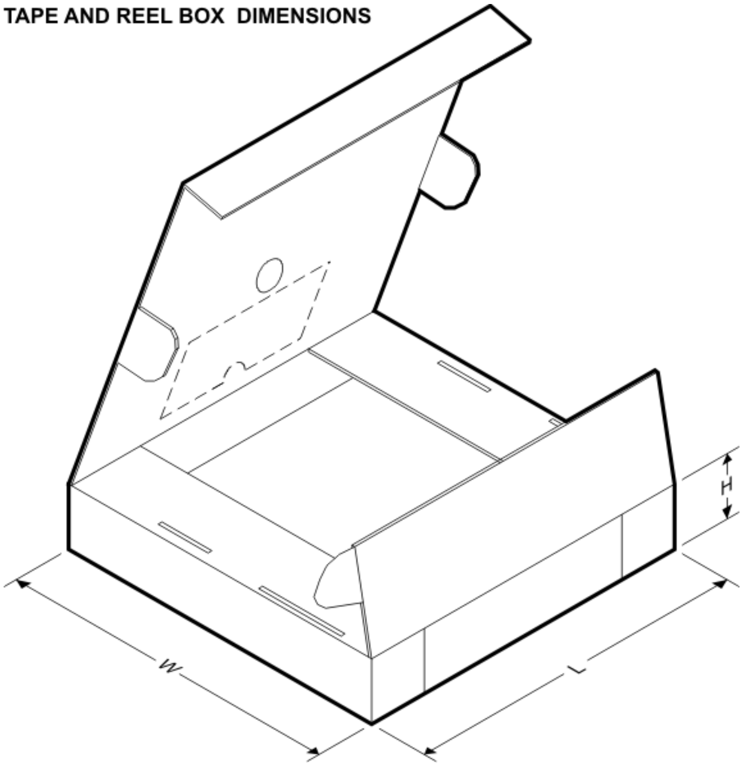
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

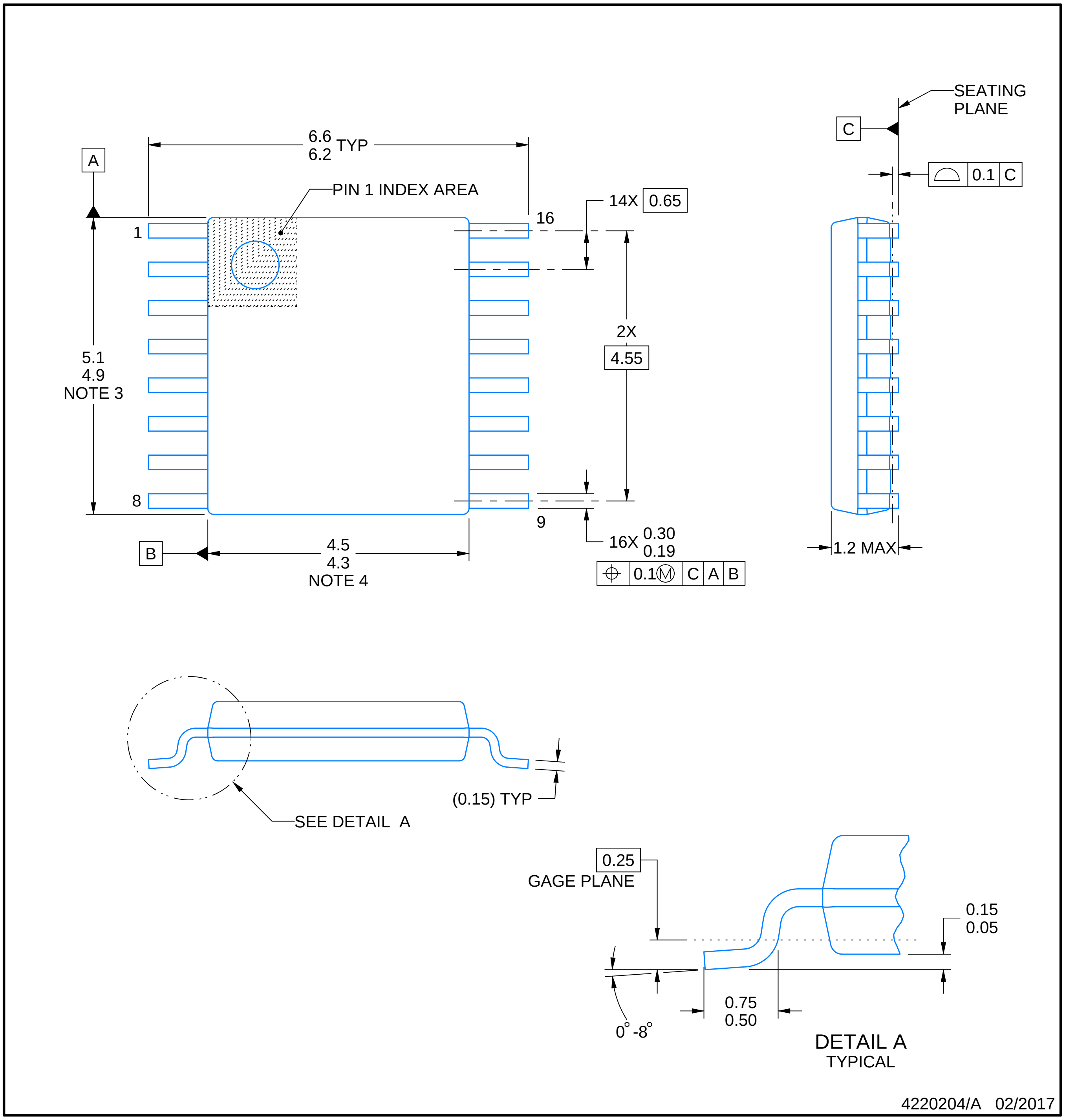
Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TL1451AQPWRG4Q1	TSSOP	PW	16	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1
TL1451AQPWRQ1	TSSOP	PW	16	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS



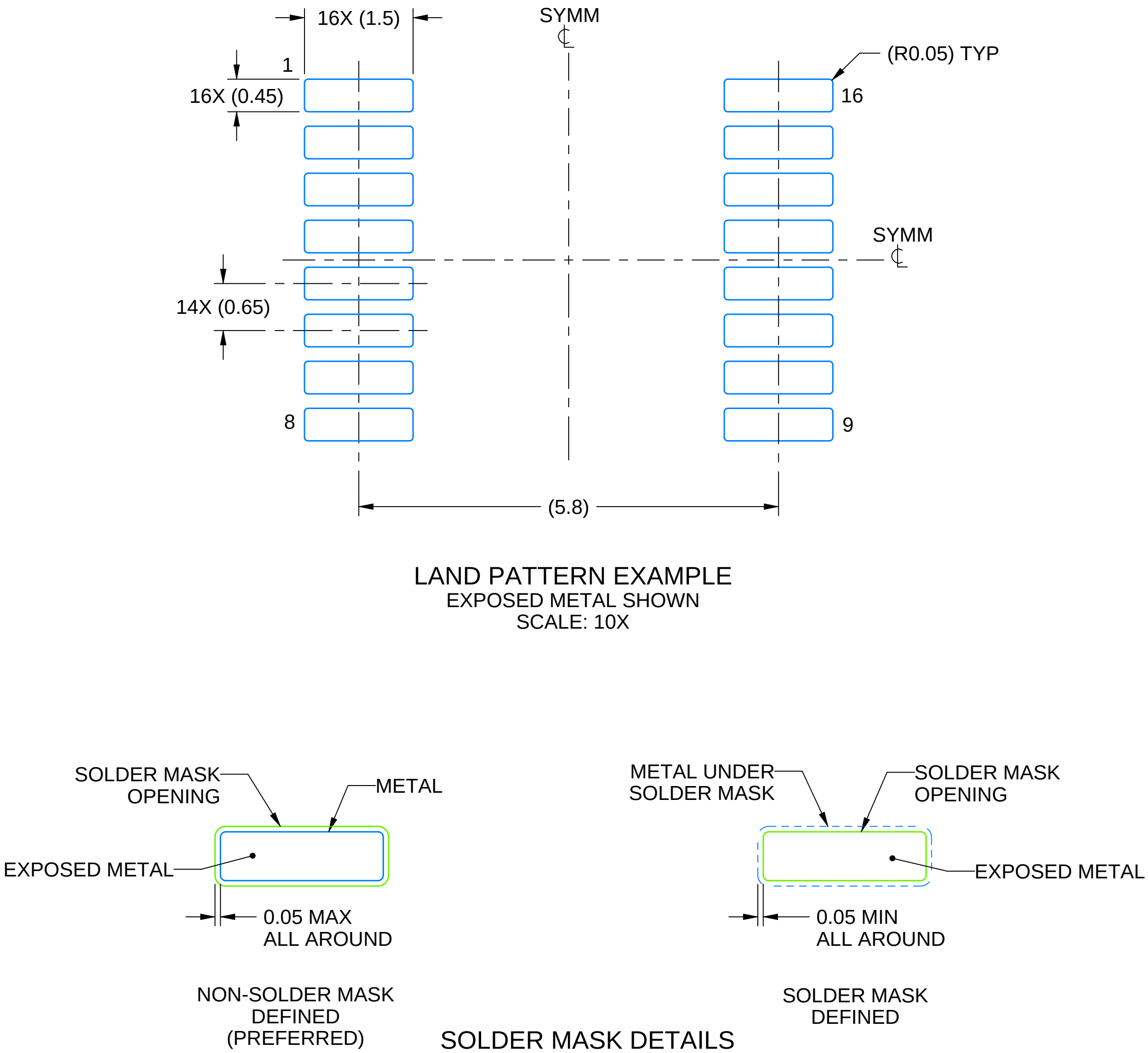
*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TL1451AQPWRG4Q1	TSSOP	PW	16	2000	367.0	367.0	35.0
TL1451AQPWRQ1	TSSOP	PW	16	2000	367.0	367.0	35.0



NOTES:

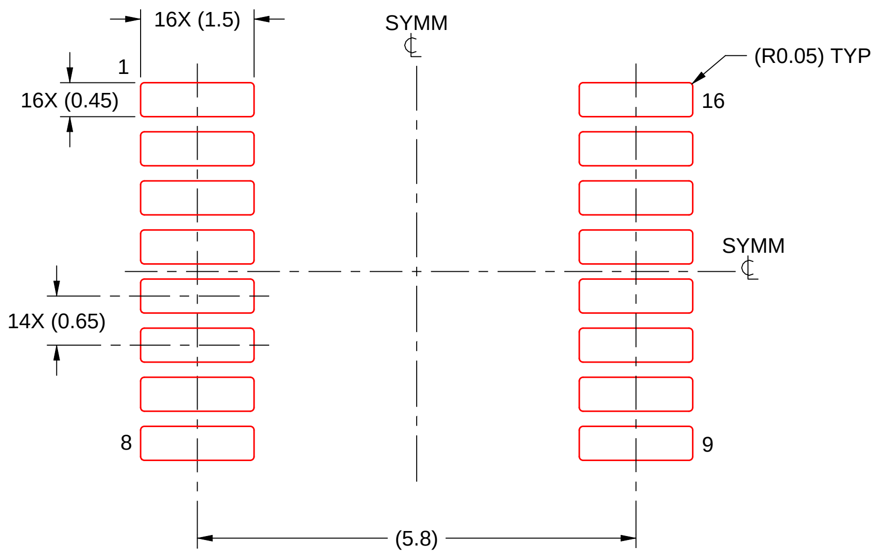
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or 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.



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.



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

4220204/A 02/2017

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.