

TL1451A

DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

SLVS024E – FEBRUARY 1983 – REVISED NOVEMBER 1999

- 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

description

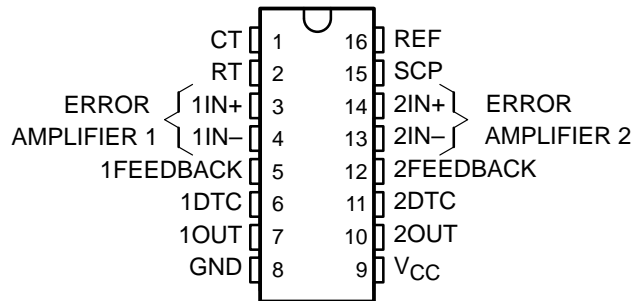
The TL1451A incorporates on a single monolithic chip all the functions required in the construction of two pulse-width-modulation (PWM) control circuits. Designed primarily for power-supply control, the TL1451A contains an on-chip 2.5-V regulator, two error amplifiers, an adjustable oscillator, two dead-time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

The uncommitted output transistors provide common-emitter output capability for each

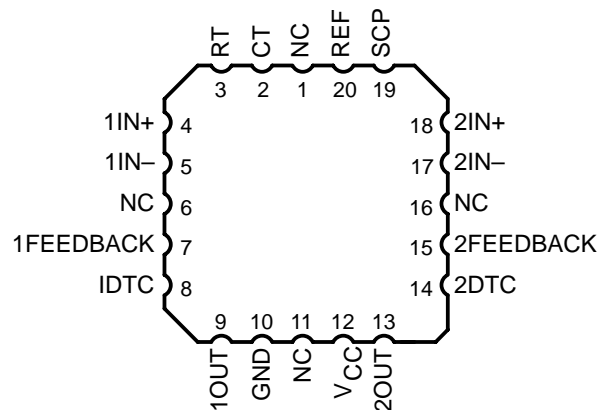
controller. The internal amplifiers exhibit a common-mode voltage range from 1.04 V to 1.45 V. The dead-time control (DTC) comparator has no offset unless externally altered and can provide 0% to 100% dead time. The on-chip oscillator can be operated by terminating RT and CT. During low V_{CC} conditions,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

The TL1451AC is characterized for operation from -20°C to 85°C . The TL1451AQ is characterized for operation from -40°C to 125°C . The TL1451AM is characterized for operation from -55°C to 125°C .

D, DB, N, NS, PW, OR J PACKAGE
(TOP VIEW)



FK PACKAGE
(TOP VIEW)



AVAILABLE OPTIONS

T _A	PACKAGED DEVICES						
	SMALL OUTLINE (D)	SMALL OUTLINE (DB) [†]	PLASTIC DIP (N)	SMALL OUTLINE (NS)	TSSOP (PW) [†]	CHIP CARRIER (FK)	CERAMIC DIP (J)
-20°C to 85°C	TL1451ACD	TL1451ACDB	TL1451ACN	TL1451ACNS	TL1451ACPW	—	—
-40°C to 125°C	TL1451AQD	—	—	—	—	—	—
-55°C to 125°C	—	—	—	—	—	TL1451AMFK	TL1451AMJ

[†] The DB and PW packages are only available left-end taped and reeled (add LE suffix, i.e., TL1451ACPWLE).



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.

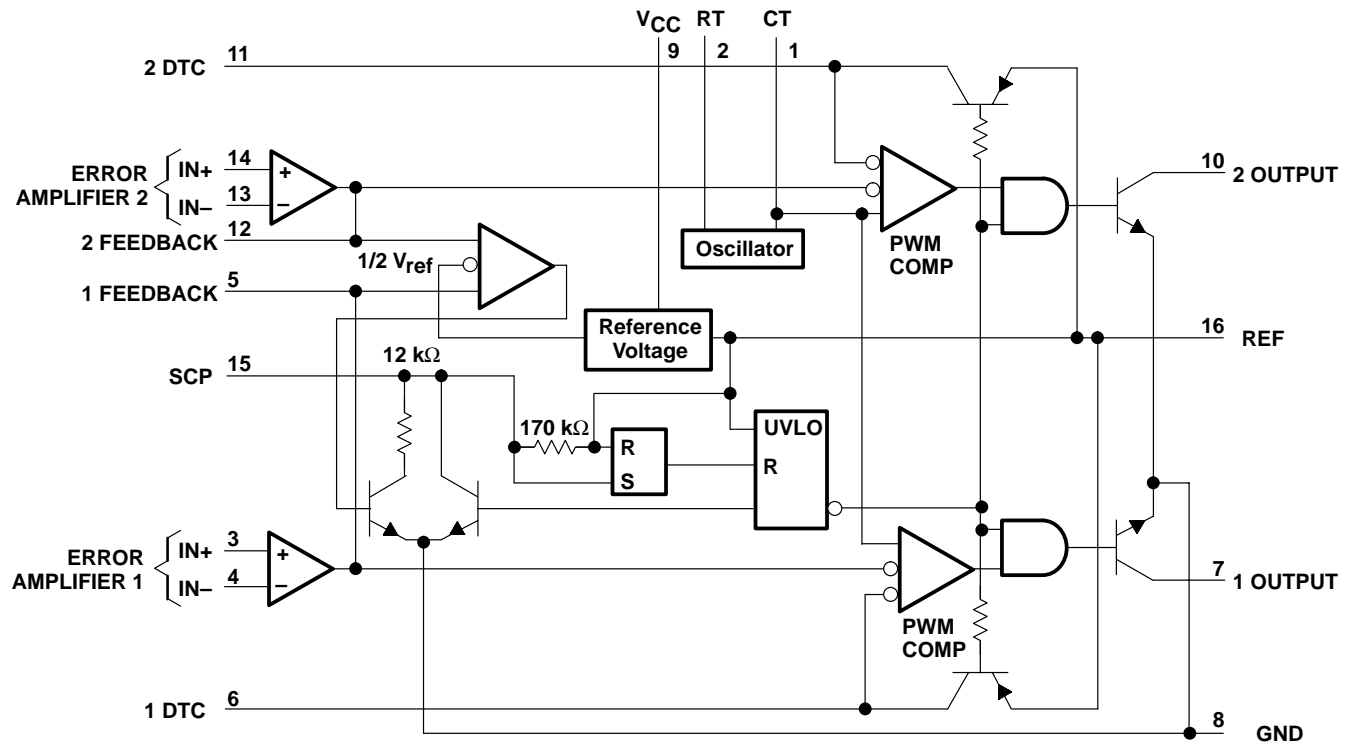
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 On products compliant to MIL-PRF-38535, all parameters are tested unless otherwise noted. On all other products, production processing does not necessarily include testing of all parameters.

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functional block diagram



COMPONENT COUNT

Resistors	65
Capacitors	8
Transistors	105
JFETs	18

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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	TL1451AC			UNIT
		MIN	TYP†	MAX	
Output voltage (pin 16)	$I_O = 1\text{ mA}$	2.4	2.5	2.6	V
Output voltage change with temperature	$T_A = -20^\circ\text{C}$ to 25°C		-0.1%	$\pm 1\%$	
	$T_A = 25^\circ\text{C}$ to 85°C		-0.2%	$\pm 1\%$	
Input voltage regulation	$V_{CC} = 3.6\text{ V}$ to 40 V		2	12.5	mV
Output voltage regulation	$I_O = 0.1\text{ mA}$ to 1 mA		1	7.5	mV
Short-circuit output current	$V_O = 0$	3	10	30	mA

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

undervoltage lockout section

PARAMETER	TEST CONDITIONS	TL1451AC			UNIT
		MIN	TYP†	MAX	
Upper threshold voltage (V_{CC})	$I_{O(\text{ref})} = 0.1\text{ mA}$, $T_A = 25^\circ\text{C}$		2.72		V
Lower threshold voltage (V_{CC})			2.6		V
Hysteresis (V_{CC})		80	120		mV
Reset threshold voltage (V_{CC})		1.5	1.9		V

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

short-circuit protection control section

PARAMETER	TEST CONDITIONS	TL1451AC			UNIT
		MIN	TYP†	MAX	
Input threshold voltage (SCP)	$T_A = 25^\circ\text{C}$	0.65	0.7	0.75	V
Standby voltage (SCP)	No pullup	140	185	230	mV
Latched input voltage (SCP)	No pullup		60	120	mV
Input (source) current	$V_I = 0.7\text{ V}$, $T_A = 25^\circ\text{C}$	-10	-15	-20	μA
Comparator threshold voltage (FEEDBACK)			1.18		V

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

oscillator section

PARAMETER	TEST CONDITIONS	TL1451C			UNIT
		MIN	TYP†	MAX	
Frequency	$C_T = 330\text{ pF}$, $R_T = 10\text{ k}\Omega$		200		kHz
Standard deviation of frequency	$C_T = 330\text{ pF}$, $R_T = 10\text{ k}\Omega$		10%		
Frequency change with voltage	$V_{CC} = 3.6\text{ V}$ to 40 V		1%		
Frequency change with temperature	$T_A = -20^\circ\text{C}$ to 25°C		-0.4%	$\pm 2\%$	
	$T_A = 25^\circ\text{C}$ to 85°C		-0.2%	$\pm 2\%$	

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

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dead-time control section

PARAMETER	TEST CONDITIONS	TL1451AC			UNIT
		MIN	TYP†	MAX	
Input bias current (DTC)				1	μA
Latch mode (source) current (DTC)	T _A = 25°C	-80	-145		μA
Latched input voltage (DTC)	I _O = 40 μA	2.3			V
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.

error-amplifier section

PARAMETER	TEST CONDITIONS	TL1451AC			UNIT
		MIN	TYP†	MAX	
Input offset voltage	V _O (FEEDBACK) = 1.25 V			±6	mV
Input offset current	V _O (FEEDBACK) = 1.25 V			±100	nA
Input bias current	V _O (FEEDBACK) = 1.25 V		160	500	nA
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	70	80		dB
Unity-gain bandwidth			1.5		MHz
Common-mode rejection ratio		60	80		dB
Positive output voltage swing				V _{ref} -0.1	V
Negative output voltage swing				1	V
Output (sink) current (FEEDBACK)	V _{ID} = -0.1 V, V _O = 1.25 V	0.5	1.6		mA
Output (source) current (FEEDBACK)	V _{ID} = 0.1 V, V _O = 1.25 V	-45	-70		μA

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

output section

PARAMETER	TEST CONDITIONS	TL1451AC			UNIT
		MIN	TYP†	MAX	
Collector off-state current	V _O = 50 V			10	μA
Output saturation voltage	I _O = 10 mA		1.2	2	V
Short-circuit output current	V _O = 6 V		90		mA

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

pwm comparator section

PARAMETER	TEST CONDITIONS	TL1451AC			UNIT
		MIN	TYP†	MAX	
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.

total device

PARAMETER	TEST CONDITIONS	TL1451AC			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.

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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, TL1451AM			UNIT
			MIN	TYP†	MAX	
Output voltage (pin 16)	$I_O = 1\text{ mA}$	$T_A = 25^\circ\text{C}$	2.40	2.50	2.60	V
		$T_A = \text{MIN and } 125^\circ\text{C}$	2.35	2.46	2.65	
Output voltage change with temperature			-0.63%		*±4%	
Input voltage regulation	$V_{CC} = 3.6\text{ V to } 40\text{ V}$	$T_A = 25^\circ\text{C}$		2.0	12.5	mV
		$T_A = 125^\circ\text{C}$		0.7	15	
		$T_A = \text{MIN}$		0.3	30	
Output voltage regulation	$I_O = 0.1\text{ mA to } 1\text{ mA}$	$T_A = 25^\circ\text{C}$		1.0	7.5	mV
		$T_A = 125^\circ\text{C}$		0.3	14	
		$T_A = \text{MIN}$		0.3	20	
Short-circuit output current	$V_O = 0$		3	10	30	mA

*These parameters are not production tested.

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

undervoltage lockout section

PARAMETER	TEST CONDITIONS		TL1451AQ, TL1451AM			UNIT
			MIN	TYP†	MAX	
Upper threshold voltage (V_{CC})		$T_A = 25^\circ\text{C}$		2.72		V
		$T_A = 125^\circ\text{C}$		1.70		
		$T_A = \text{MIN}$		3.15		
Lower threshold voltage (V_{CC})		$T_A = 25^\circ\text{C}$		2.60		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})		$T_A = 25^\circ\text{C}$		1.50		V
		$T_A = 125^\circ\text{C}$		0.95		
		$T_A = \text{MIN}$		1.50		

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short-circuit protection control section

PARAMETER	TEST CONDITIONS	TL1451AQ, TL1451AM			UNIT
		MIN	TYP†	MAX	
Input threshold voltage (SCP)	T _A = 25°C	650	700	750	mV
	T _A = 125°C	400	478	550	
	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, TL1451AM			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%		

*These parameters are not production tested.

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

dead-time control section

PARAMETER	TEST CONDITIONS	TL1451AQ, TL1451AM			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	2.30		V	
	T _A = 125°C	2.22	2.32		
	T _A = MIN	2.28	2.40		
Input threshold voltage at f = 10 kHz (DTC)	Zero duty cycle		2.05	*2.25	V
	Maximum duty cycle	*1.20	1.45		

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error-amplifier section

PARAMETER	TEST CONDITIONS	TL1451AQ, TL1451AM			UNIT
		MIN	TYP†	MAX	
Input offset voltage	V_O (FEEDBACK) = 1.25 V	$T_A = 25^\circ\text{C}$		±6	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, TL1451AM			UNIT
		MIN	TYP†	MAX	
Collector off-state current	$V_O = 50 \text{ V}$			10	μA
Output saturation voltage	$T_A = 25^\circ\text{C}$		1.20	2.0	V
	$T_A = 125^\circ\text{C}$		1.60	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, TL1451AM			UNIT
		MIN	TYP†	MAX	
Input threshold voltage at $f = 10 \text{ kHz}$ (FEEDBACK)	Zero duty cycle		2.05	*2.25	V
	Maximum duty cycle	*1.20	1.45		

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total device

PARAMETER	TEST CONDITIONS	TL1451AQ, TL1451AM			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

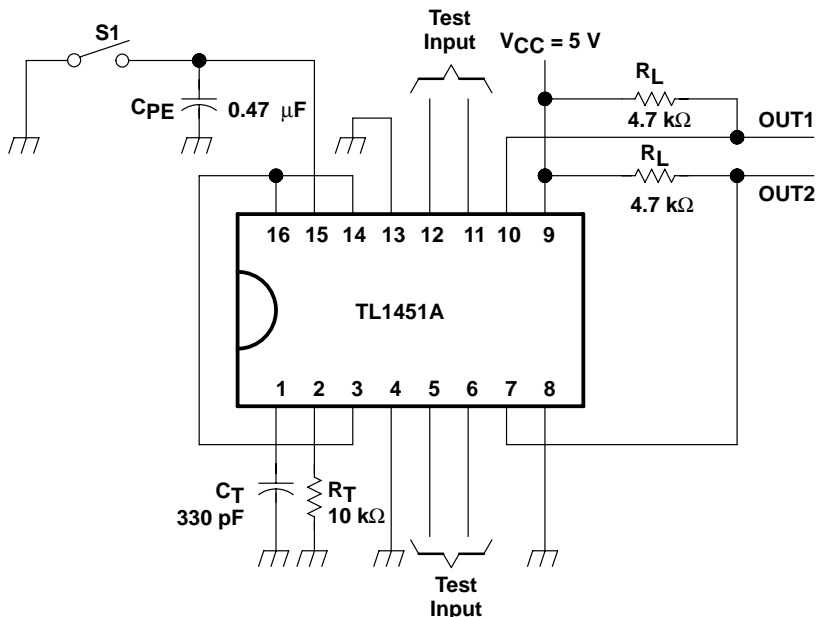
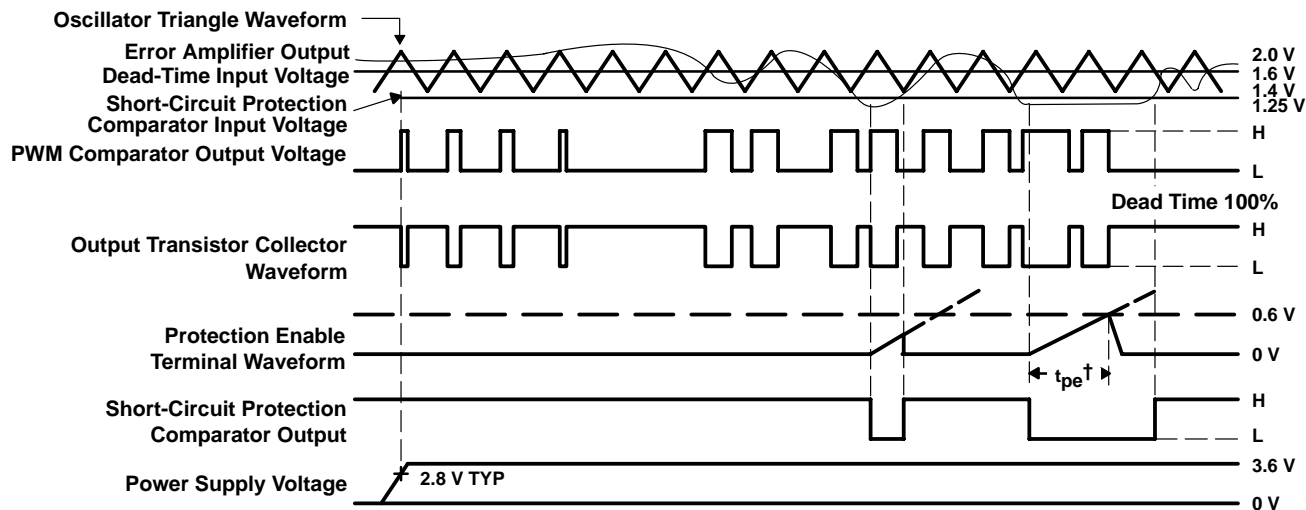


Figure 1. Test Circuit



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

Figure 2. TL1451A Timing Diagram

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TYPICAL CHARACTERISTICS

TRIANGLE OSCILLATOR FREQUENCY
vs
TIMING RESISTANCE

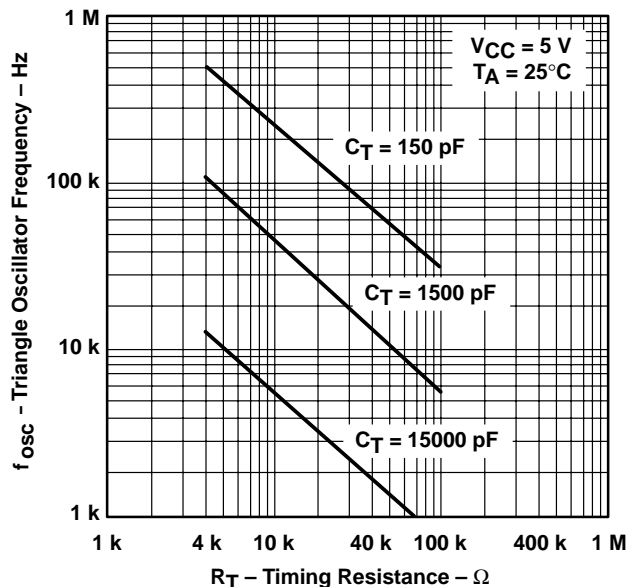


Figure 3

OSCILLATOR FREQUENCY VARIATION
vs
FREE-AIR TEMPERATURE

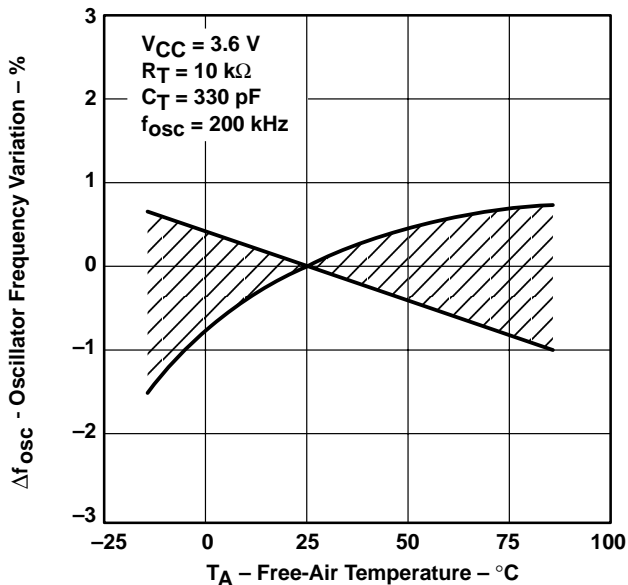


Figure 4

TRIANGLE WAVEFORM SWING VOLTAGE
vs
TIMING CAPACITANCE

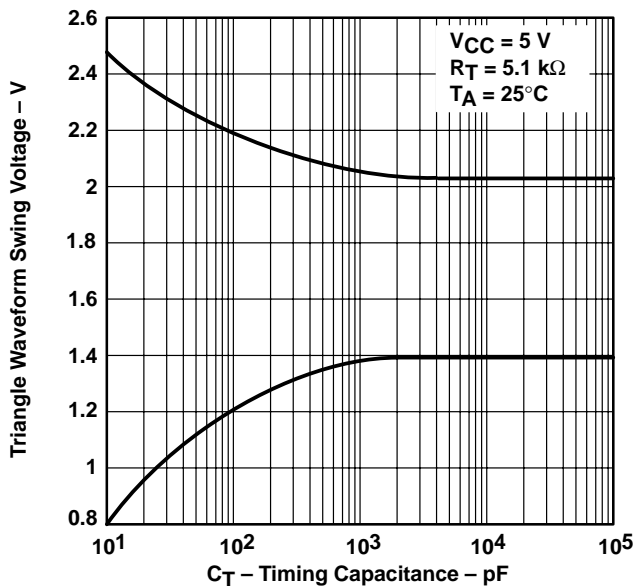


Figure 5

TRIANGLE WAVEFORM PERIOD
vs
TIMING CAPACITANCE

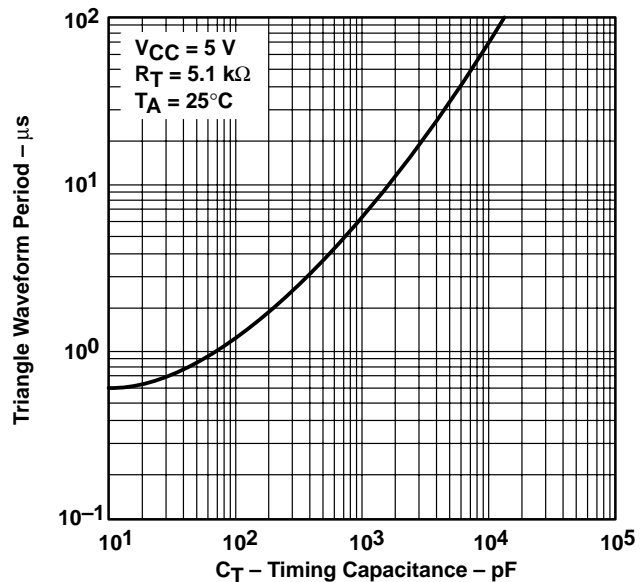


Figure 6

TYPICAL CHARACTERISTICS

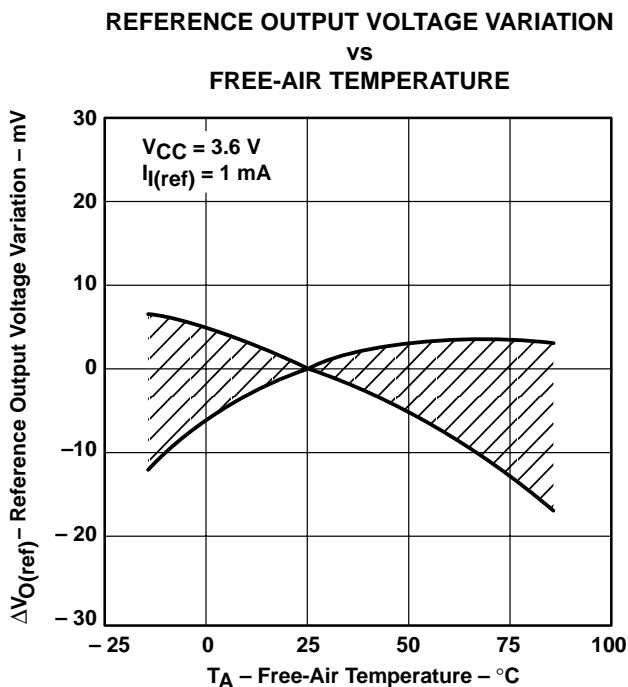


Figure 7

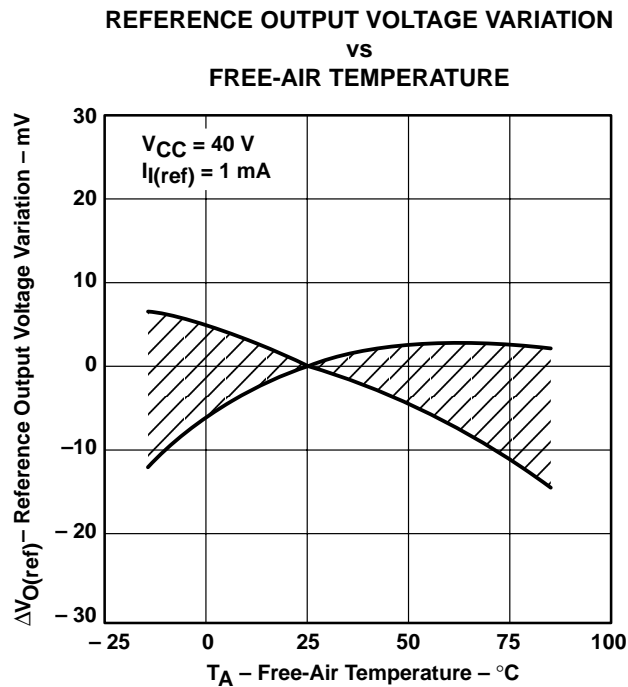


Figure 8

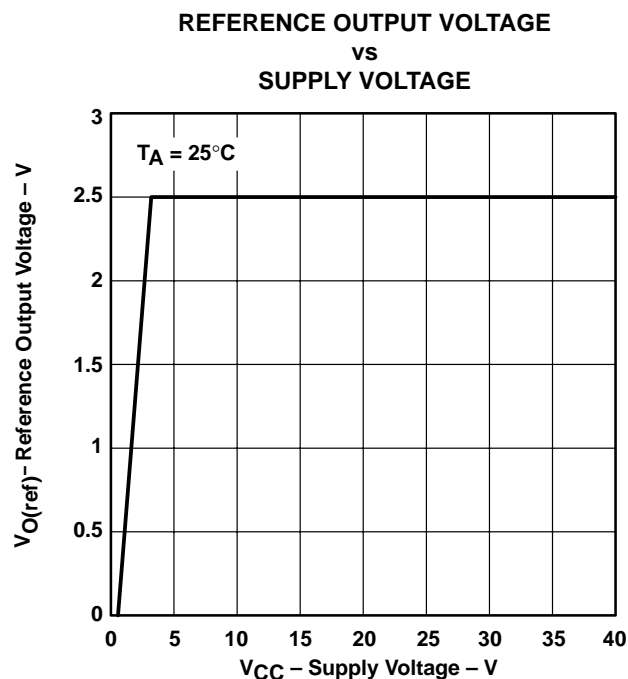


Figure 9

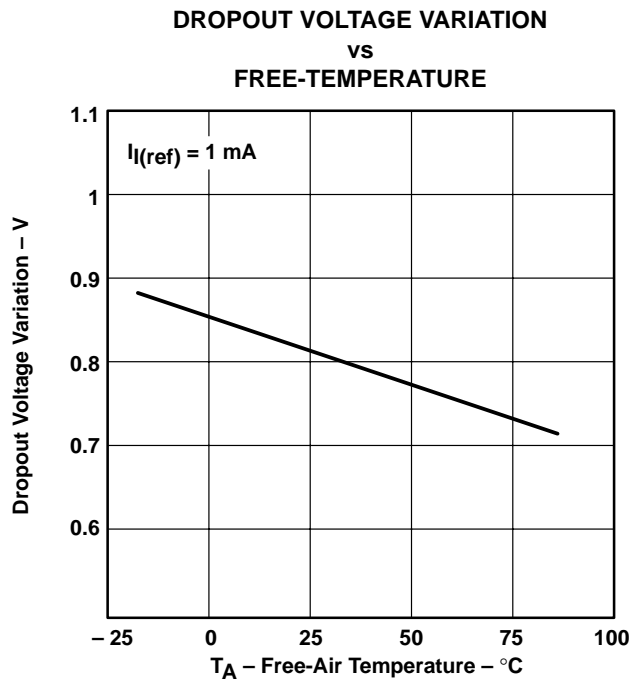


Figure 10

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TYPICAL CHARACTERISTICS

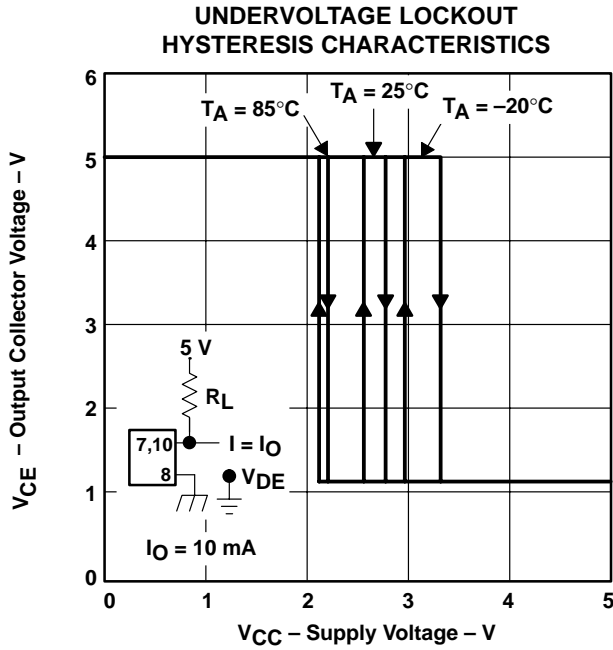


Figure 11

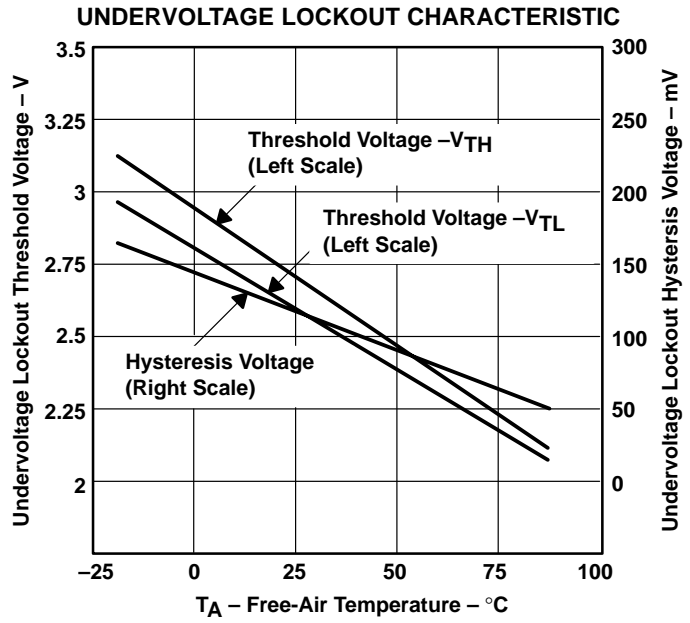


Figure 12

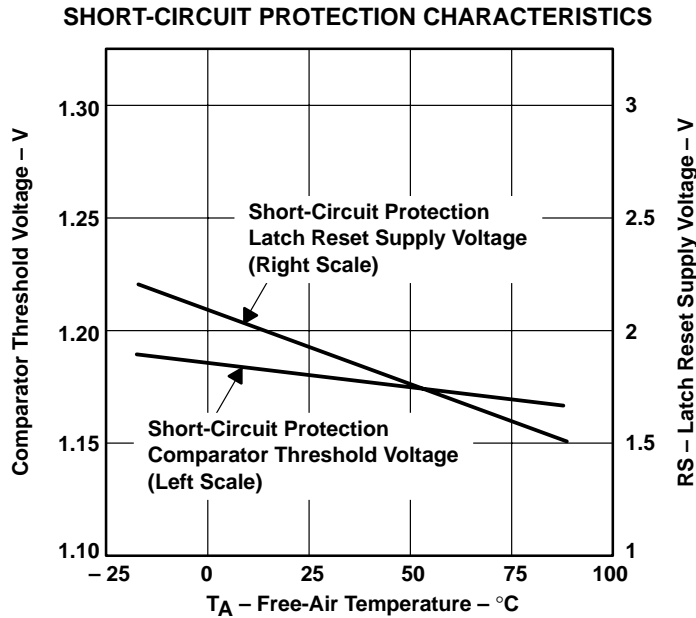


Figure 13

TL1451A DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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TYPICAL CHARACTERISTICS

**ERROR AMP MAXIMUM OUTPUT VOLTAGE SWING
vs
FREQUENCY**

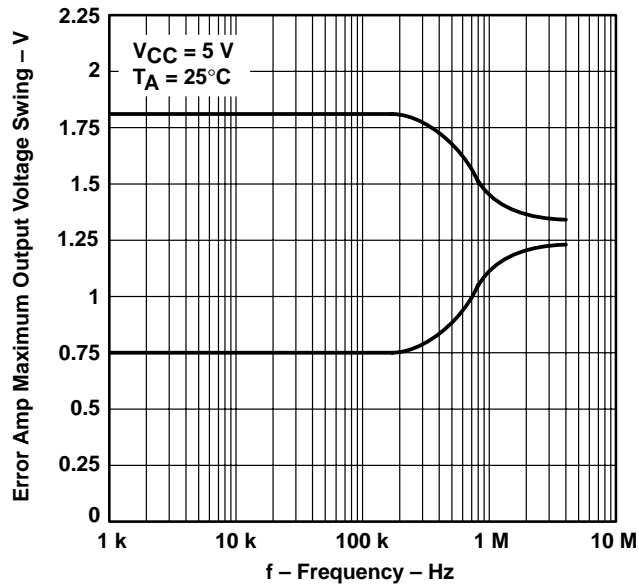


Figure 15

**OPEN-LOOP VOLTAGE AMPLIFICATION
vs
FREQUENCY**

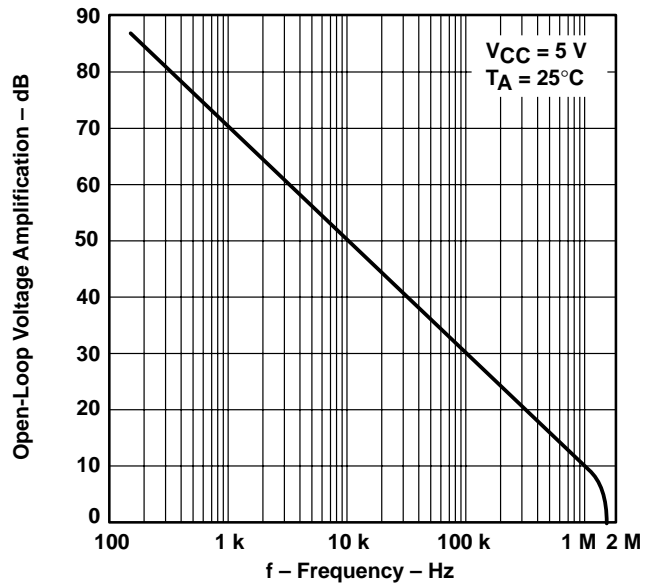


Figure 16

**GAIN (AMPLIFIER IN
UNITY-GAIN CONFIGURATION)
vs
FREQUENCY**

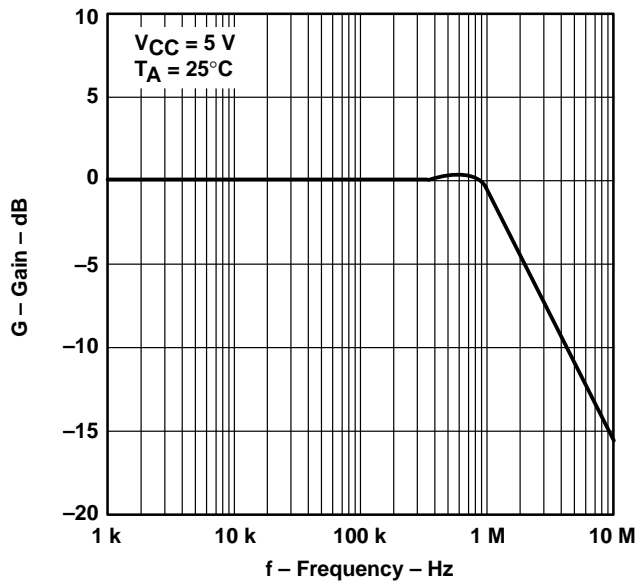
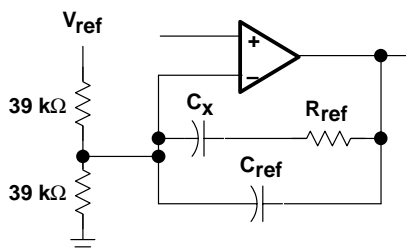
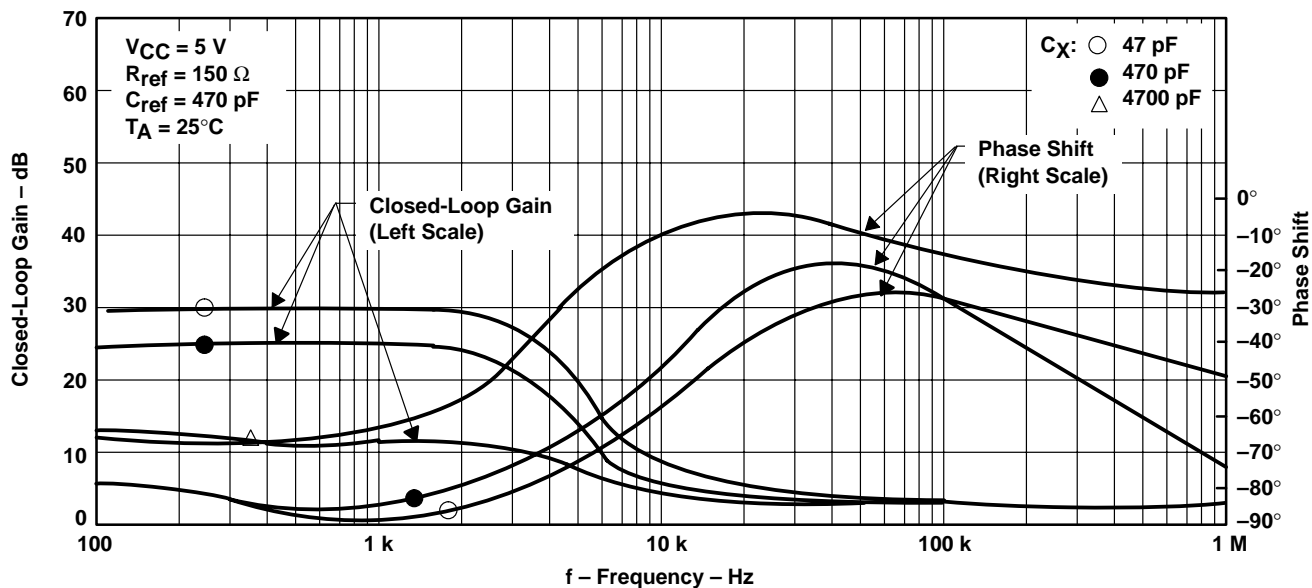


Figure 17

TYPICAL CHARACTERISTICS

CLOSED-LOOP GAIN AND PHASE SHIFT vs FREQUENCY



Test Circuit

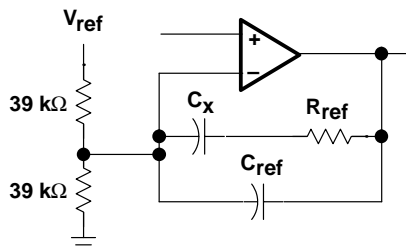
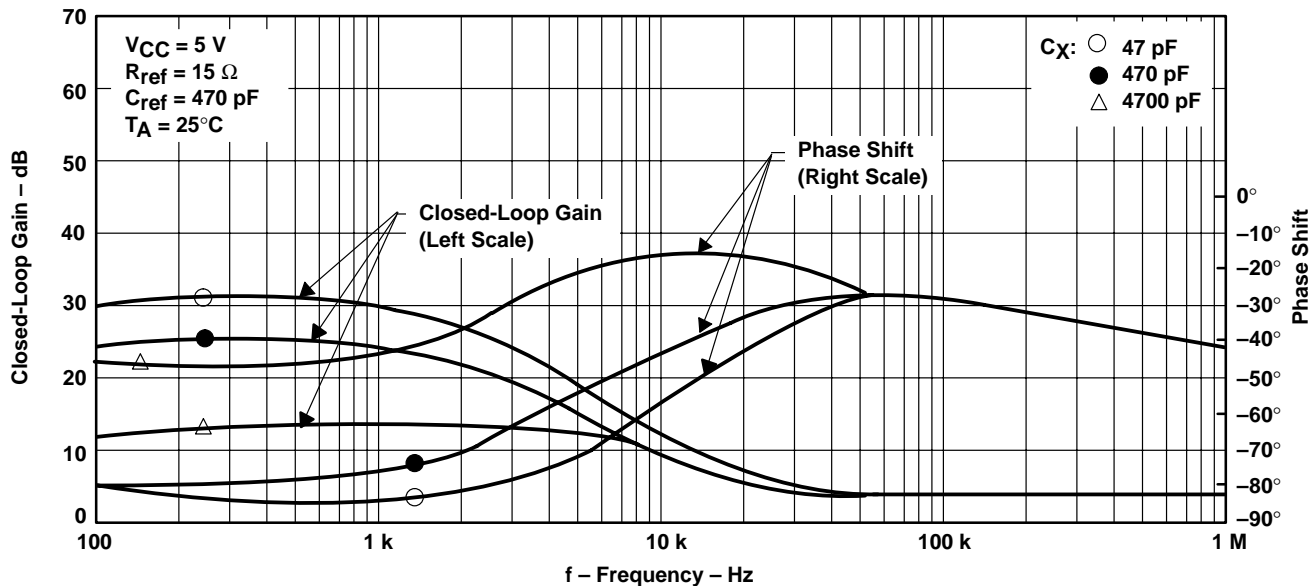
Figure 18

TL1451A DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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TYPICAL CHARACTERISTICS

CLOSED-LOOP GAIN AND PHASE SHIFT vs FREQUENCY

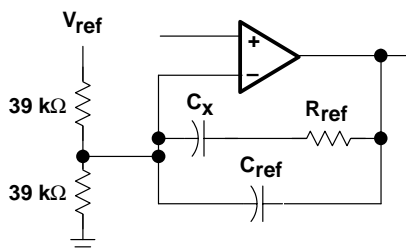
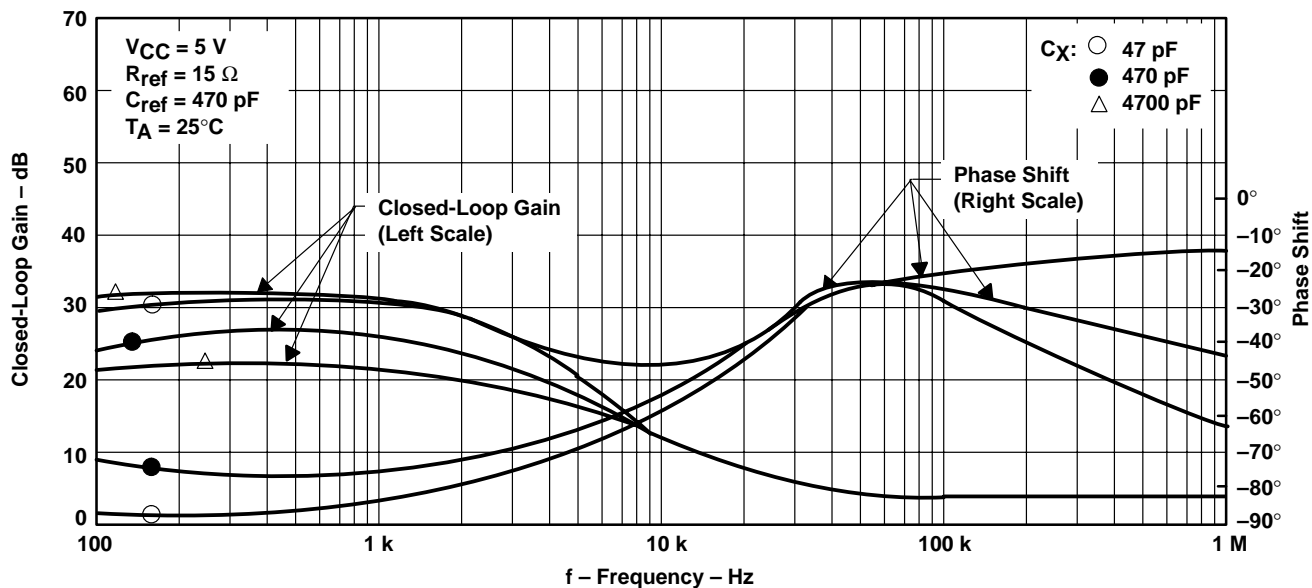


Test Circuit

Figure 19

TYPICAL CHARACTERISTICS

CLOSED-LOOP GAIN AND PHASE SHIFT VS FREQUENCY



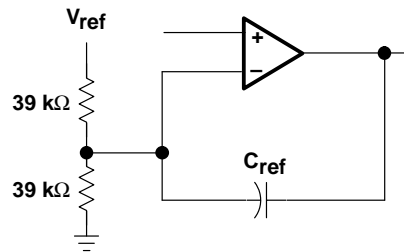
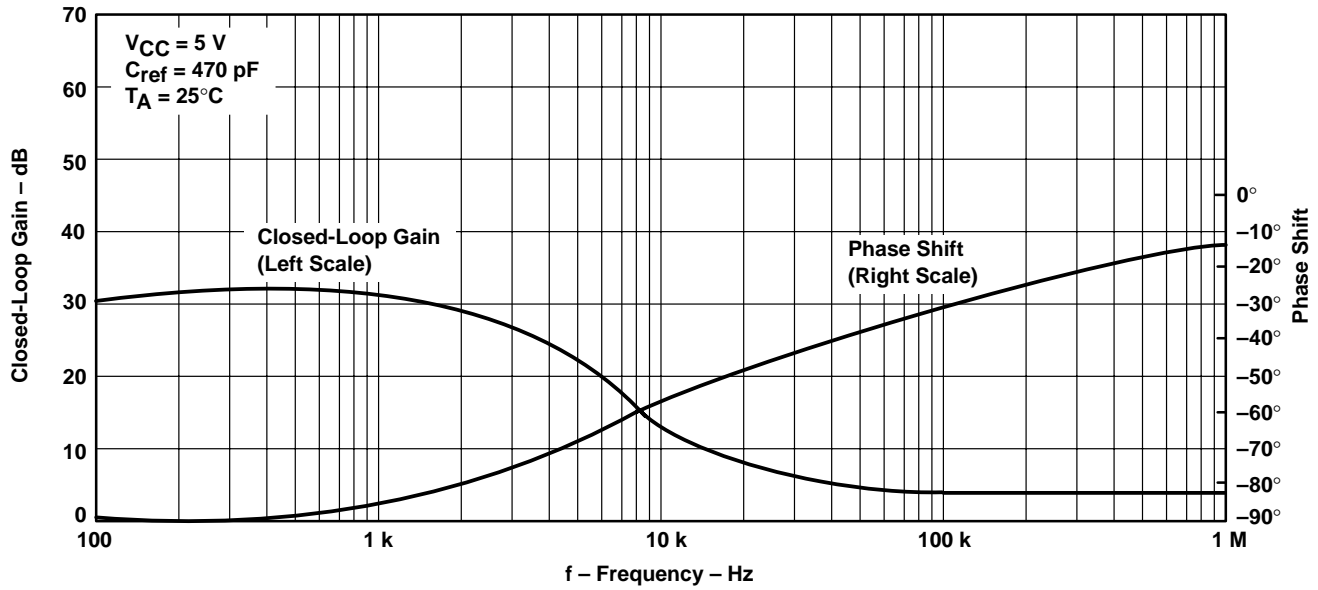
Test Circuit

Figure 20

TL1451A 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

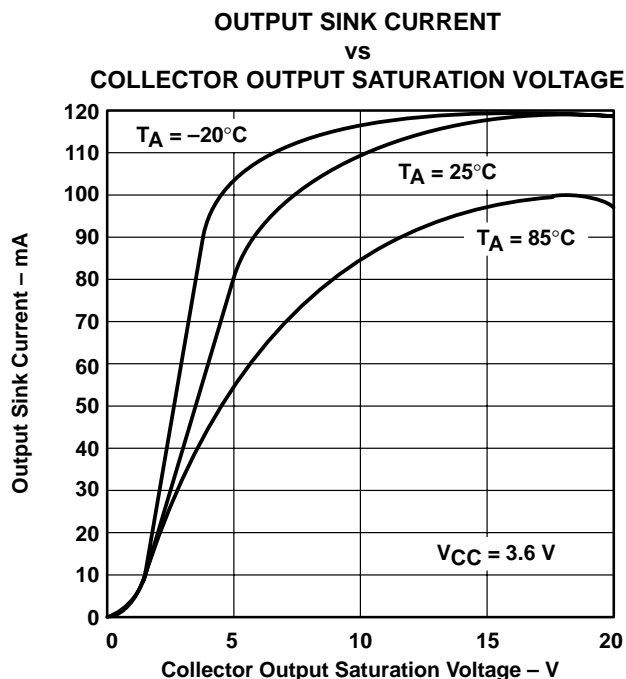


Figure 22

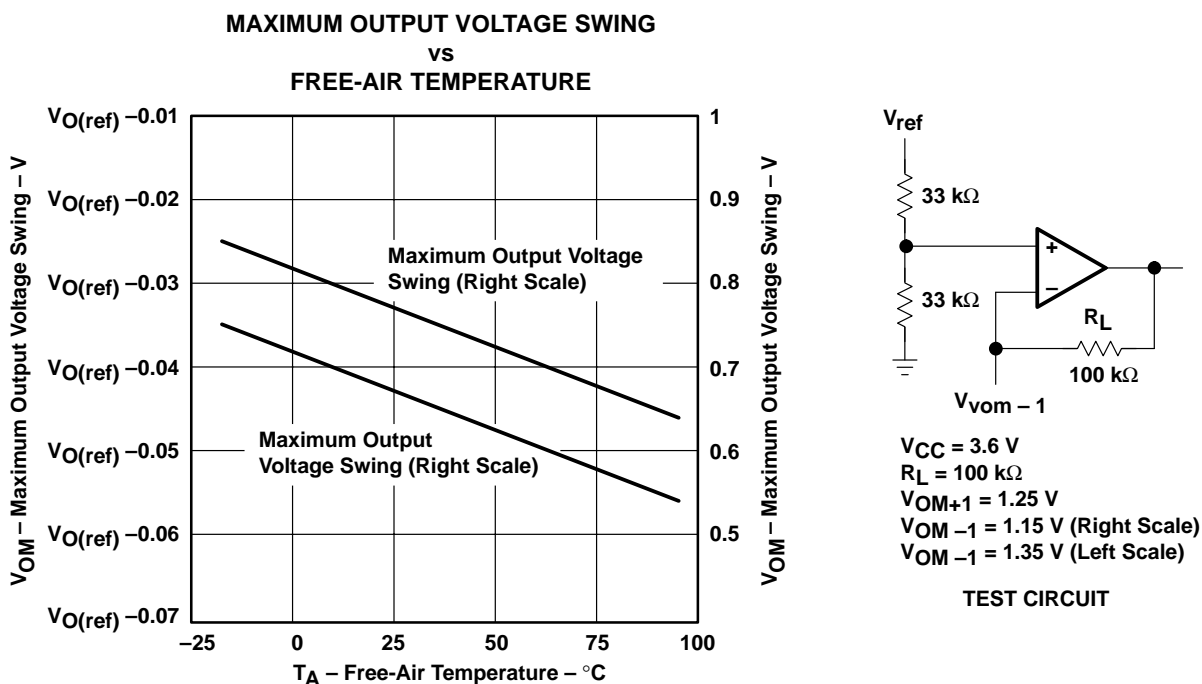
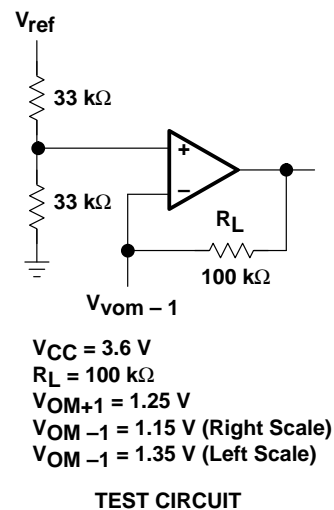


Figure 23



TL1451A DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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TYPICAL CHARACTERISTICS

OUTPUT TRANSISTOR ON DUTY CYCLE
vs
DEAD-TIME INPUT VOLTAGE

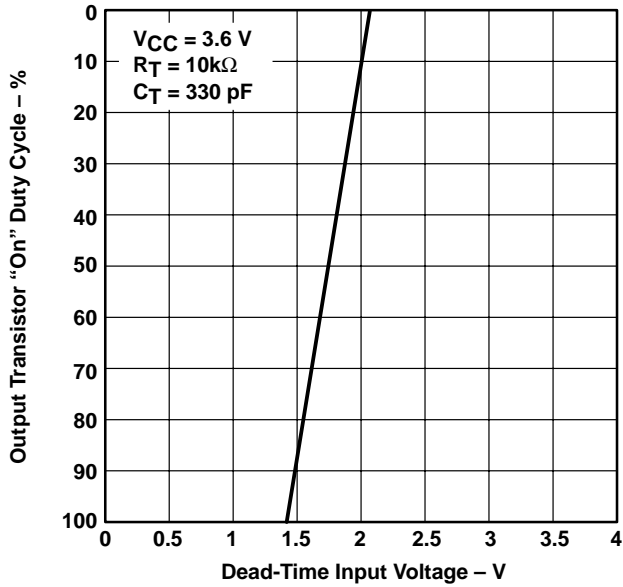


Figure 24

STANDBY CURRENT
vs
SUPPLY VOLTAGE

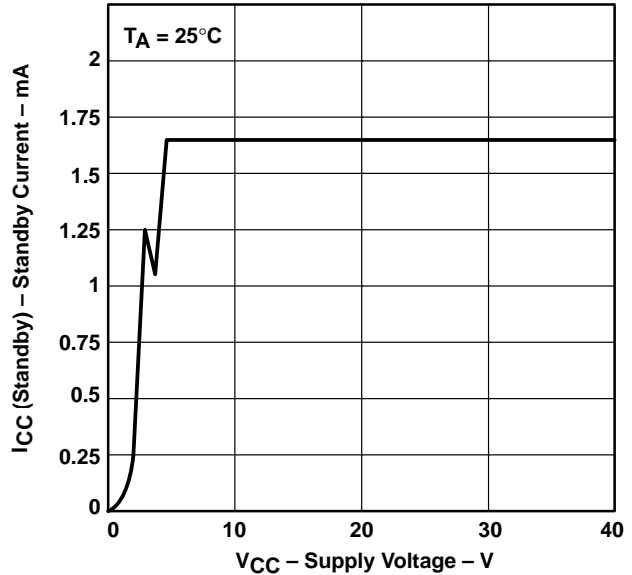


Figure 25

STANDBY CURRENT
vs
FREE-AIR TEMPERATURE

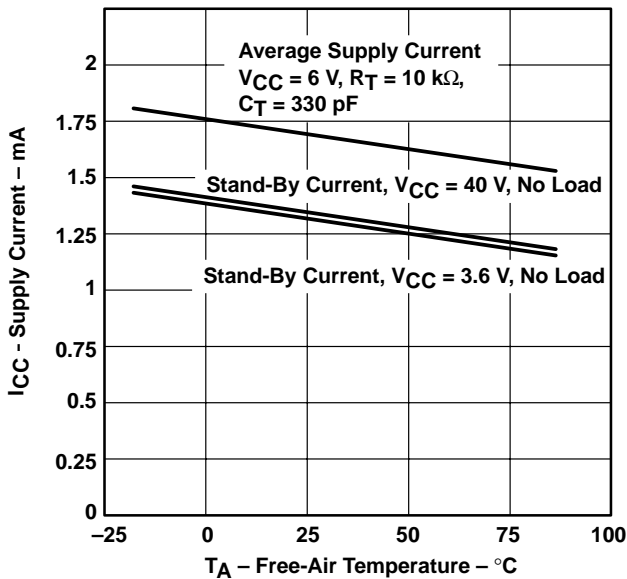


Figure 26

MAXIMUM CONTINUOUS POWER DISSIPATION
vs
FREE-AIR TEMPERATURE

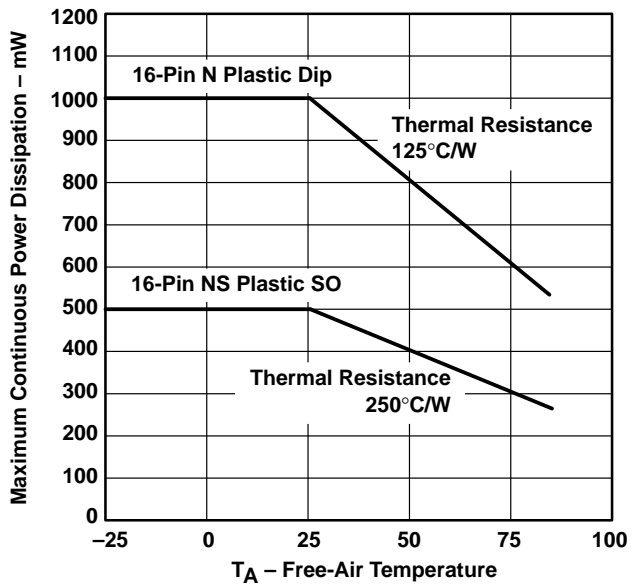
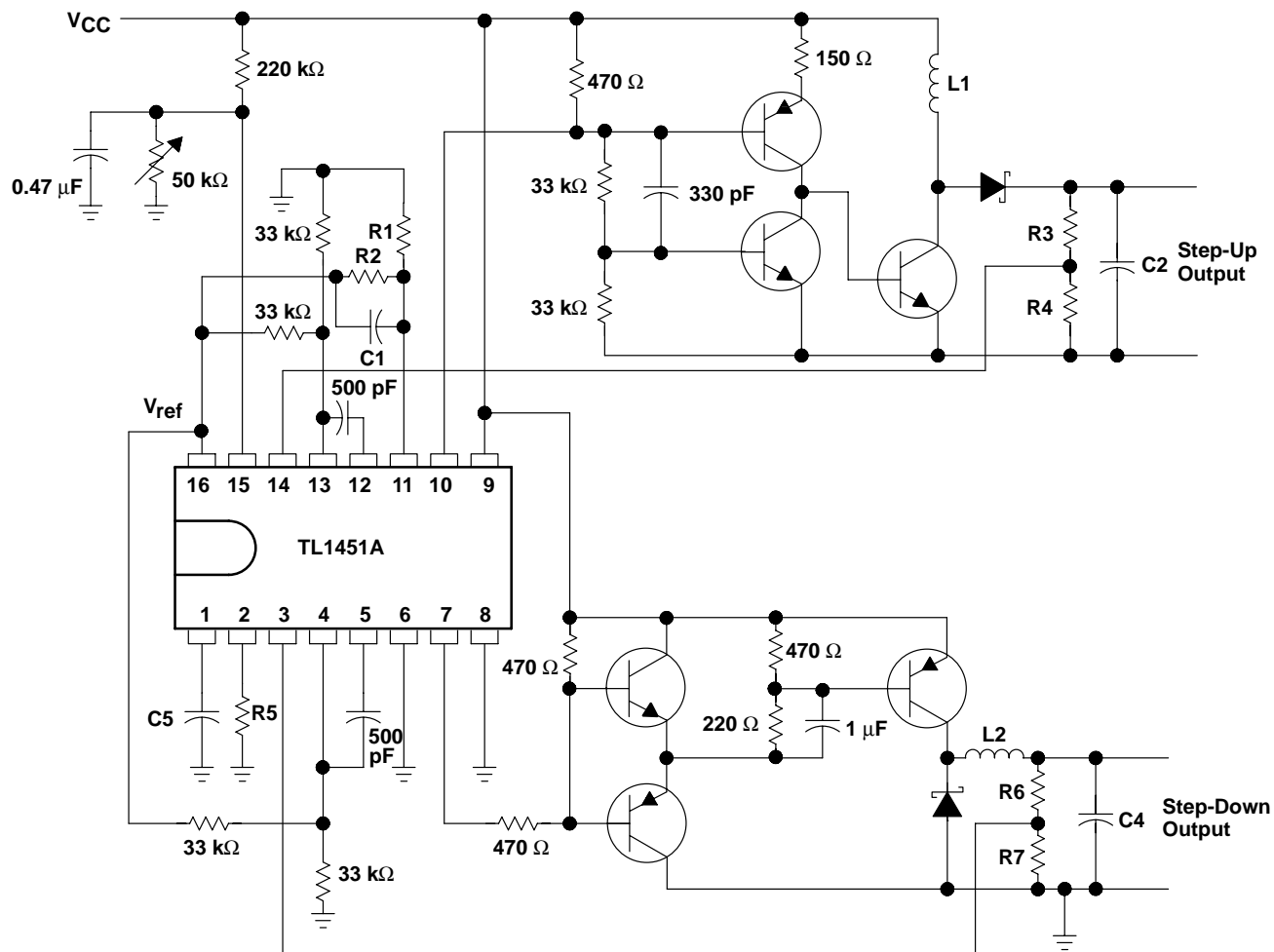


Figure 27

TL1451A DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

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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

TL1451A DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

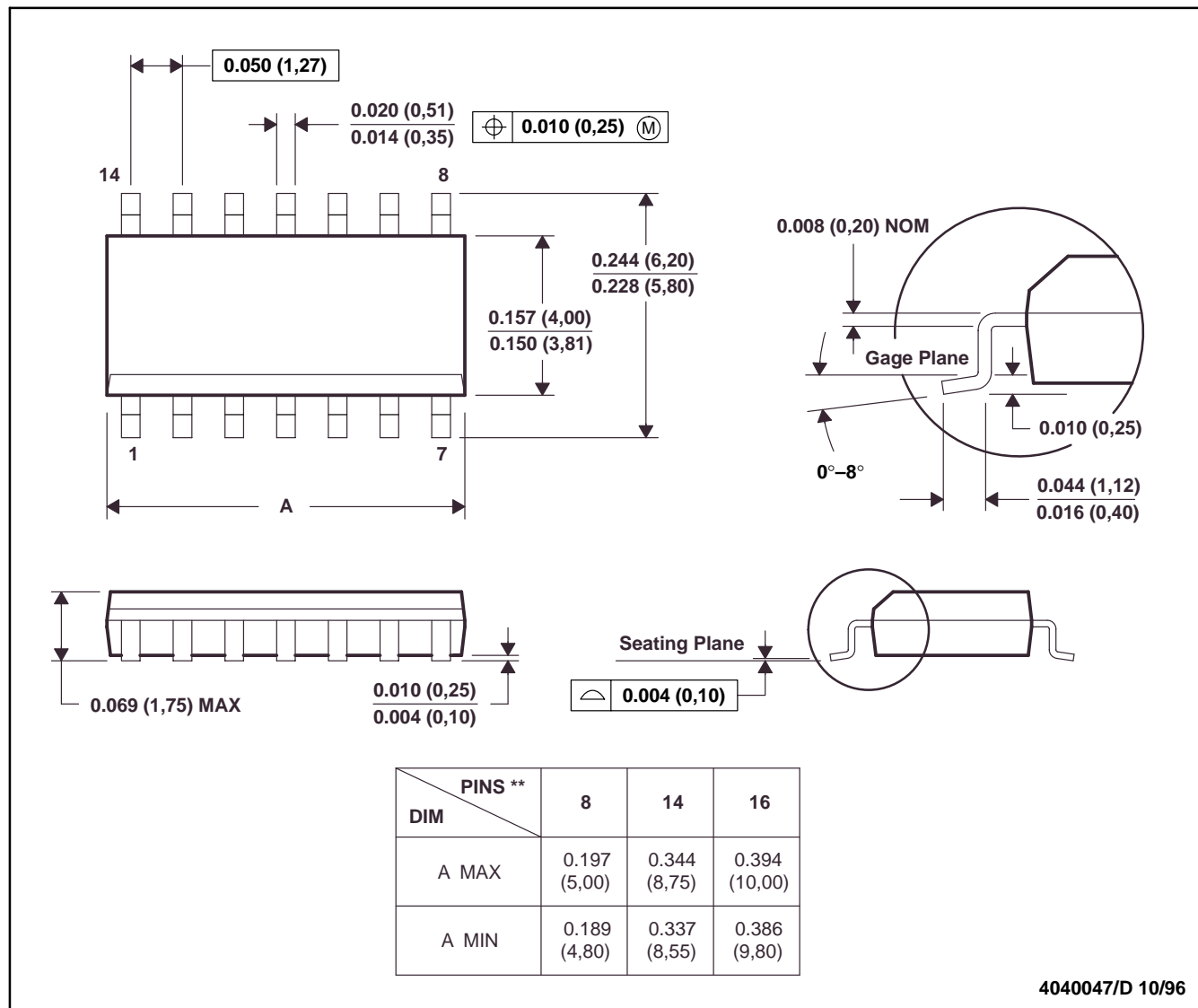
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MECHANICAL DATA

D (R-PDSO-G**)

PLASTIC SMALL-OUTLINE PACKAGE

14 PINS SHOWN



- NOTES: A. All linear dimensions are in inches (millimeters).
 B. This drawing is subject to change without notice.
 C. Body dimensions do not include mold flash or protrusion, not to exceed 0.006 (0,15).
 D. Falls within JEDEC MS-012

TL1451A DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

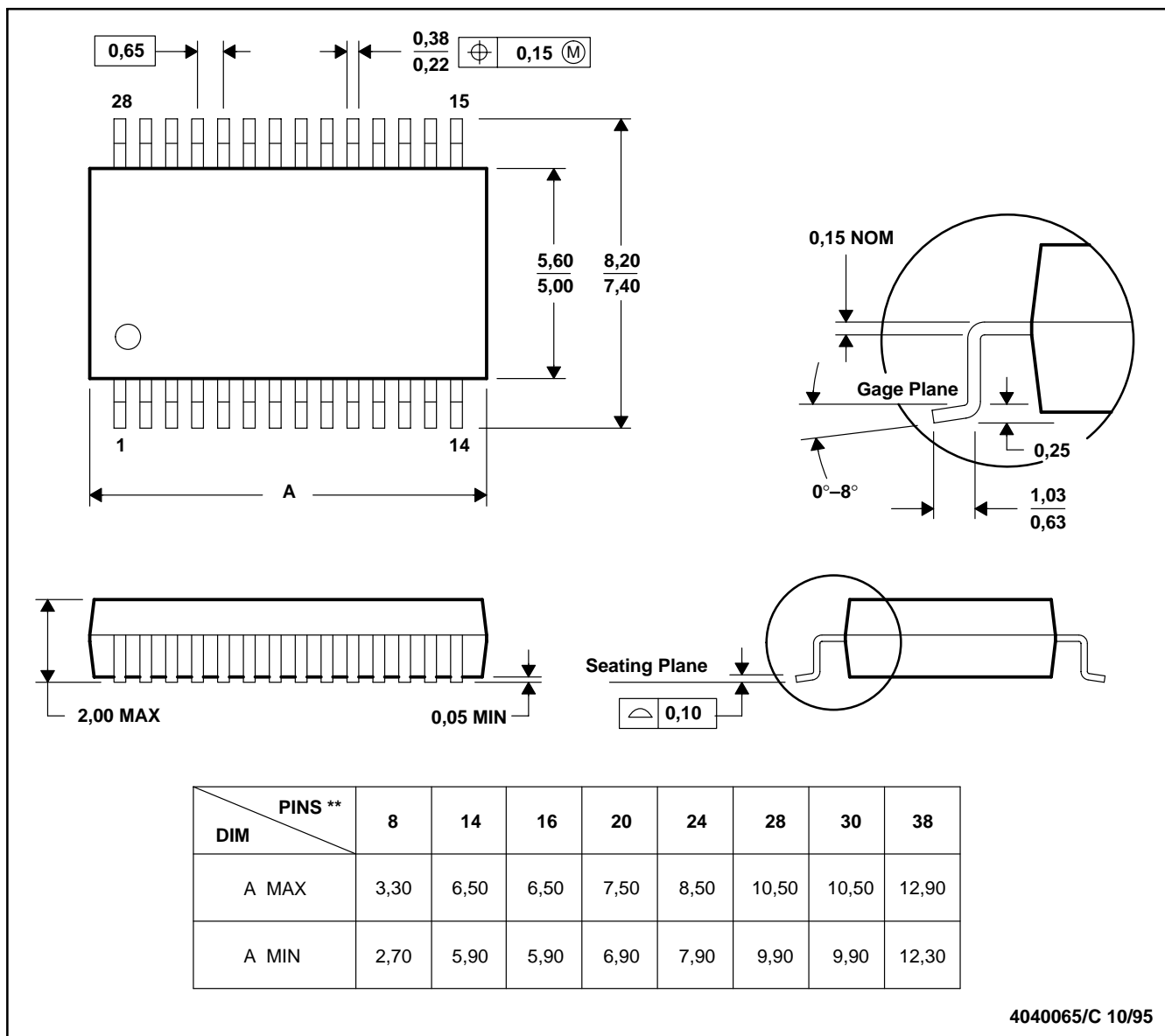
SLVS024E – FEBRUARY 1983 – REVISED NOVEMBER 1999

MECHANICAL DATA

DB (R-PDSO-G)**

PLASTIC SMALL-OUTLINE PACKAGE

28 PINS SHOWN



- NOTES: A. All linear dimensions are in millimeters.
 B. This drawing is subject to change without notice.
 C. Body dimensions do not include mold flash or protrusion not to exceed 0,15.
 D. Falls within JEDEC MO-150

TL1451A DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

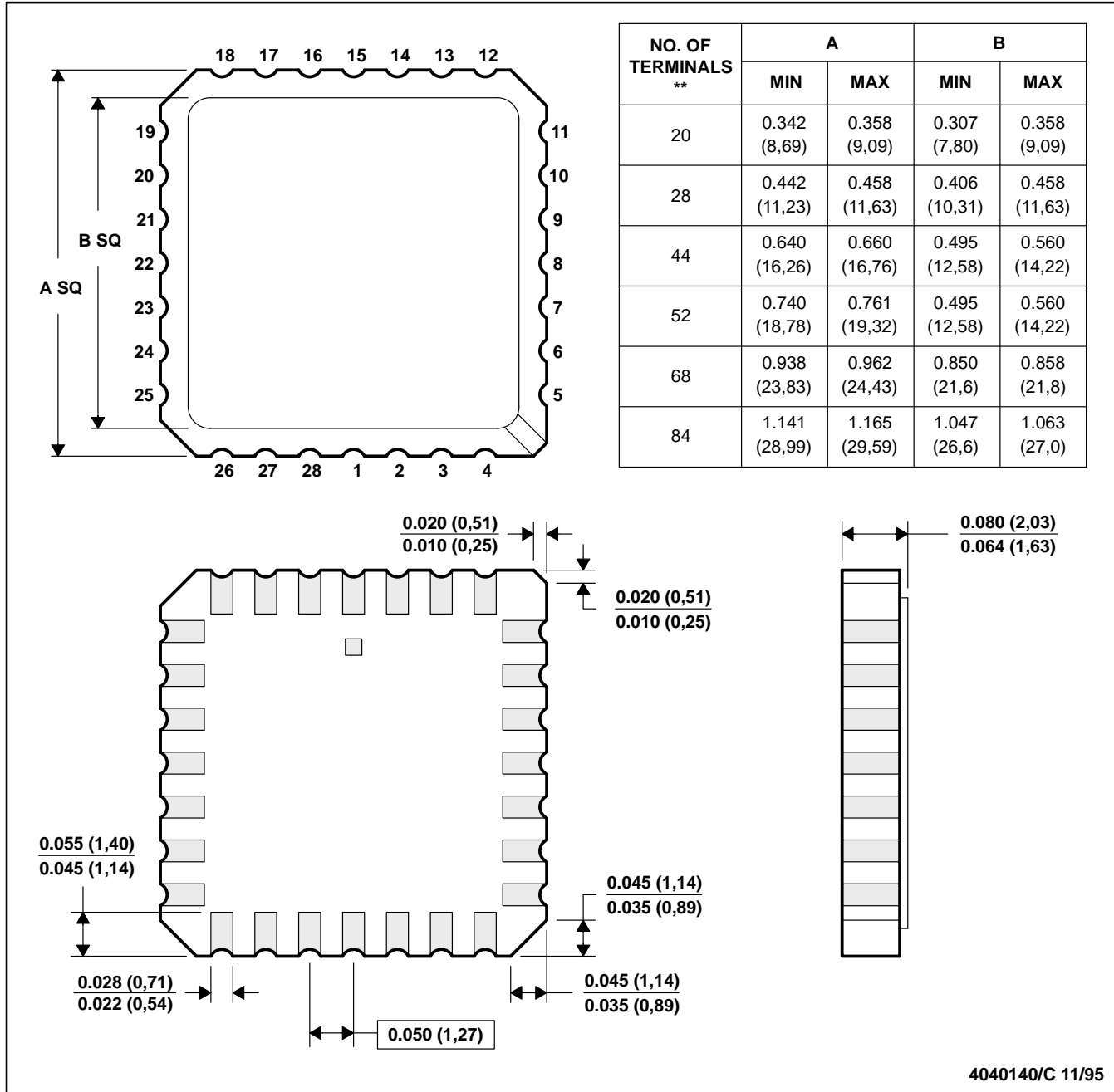
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MECHANICAL DATA

FK (S-CQCC-N**)

LEADLESS CERAMIC CHIP CARRIER

28 TERMINALS SHOWN



4040140/C 11/95

- NOTES: A. All linear dimensions are in inches (millimeters).
 B. This drawing is subject to change without notice.
 C. This package can be hermetically sealed with a metal lid.
 D. The terminals are gold-plated.
 E. Falls within JEDEC MS-004

TL1451A DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

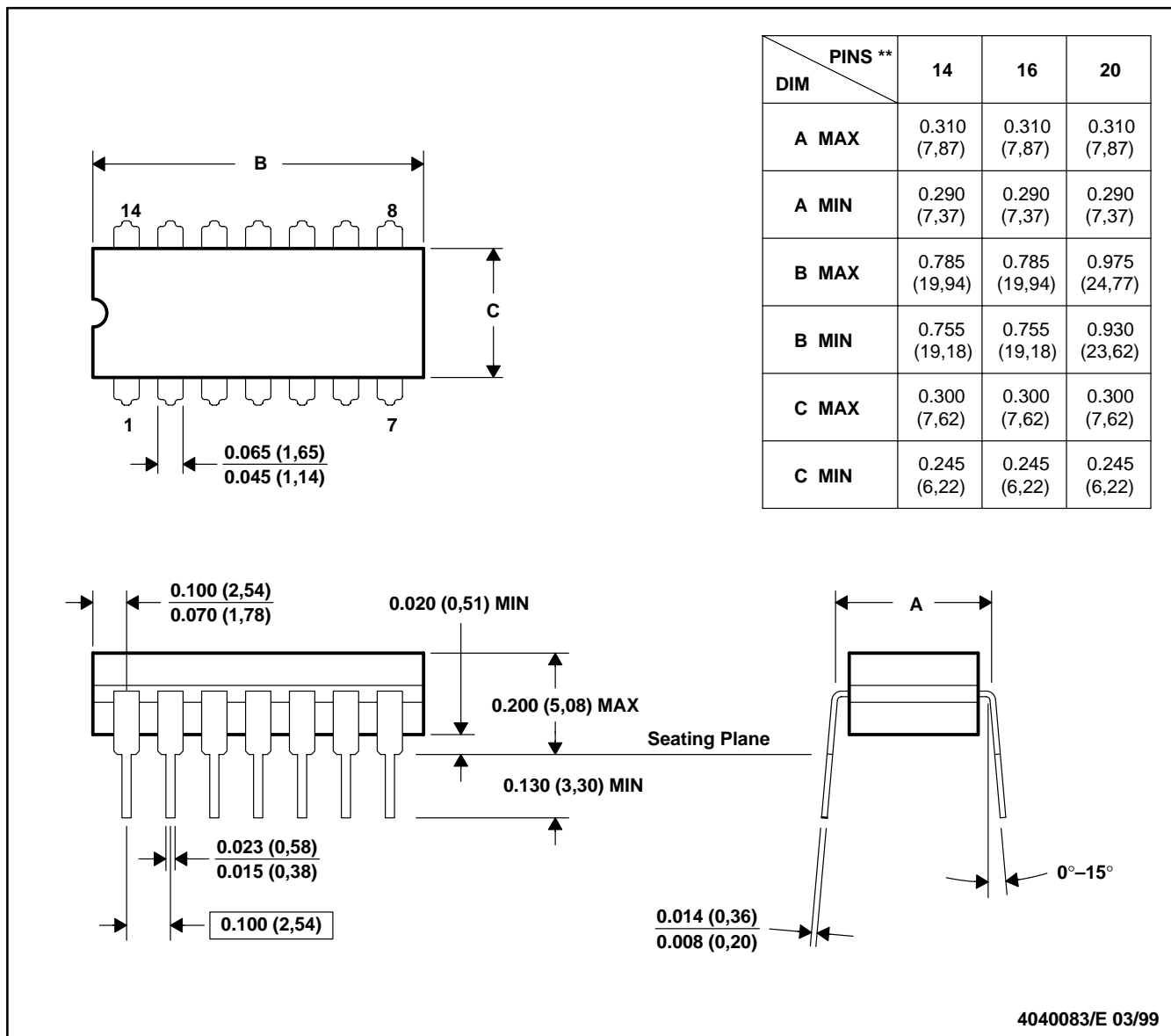
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MECHANICAL DATA

J (R-GDIP-T)**

CERAMIC DUAL-IN-LINE

14 LEADS SHOWN



- NOTES:
- A. All linear dimensions are in inches (millimeters).
 - B. This drawing is subject to change without notice.
 - C. This package is hermetically sealed with a ceramic lid using glass frit.
 - D. Index point is provided on cap for terminal identification.
 - E. Falls within MIL STD 1835 GDIP1-T14, GDIP1-T16, and GDIP1-T20

TL1451A DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

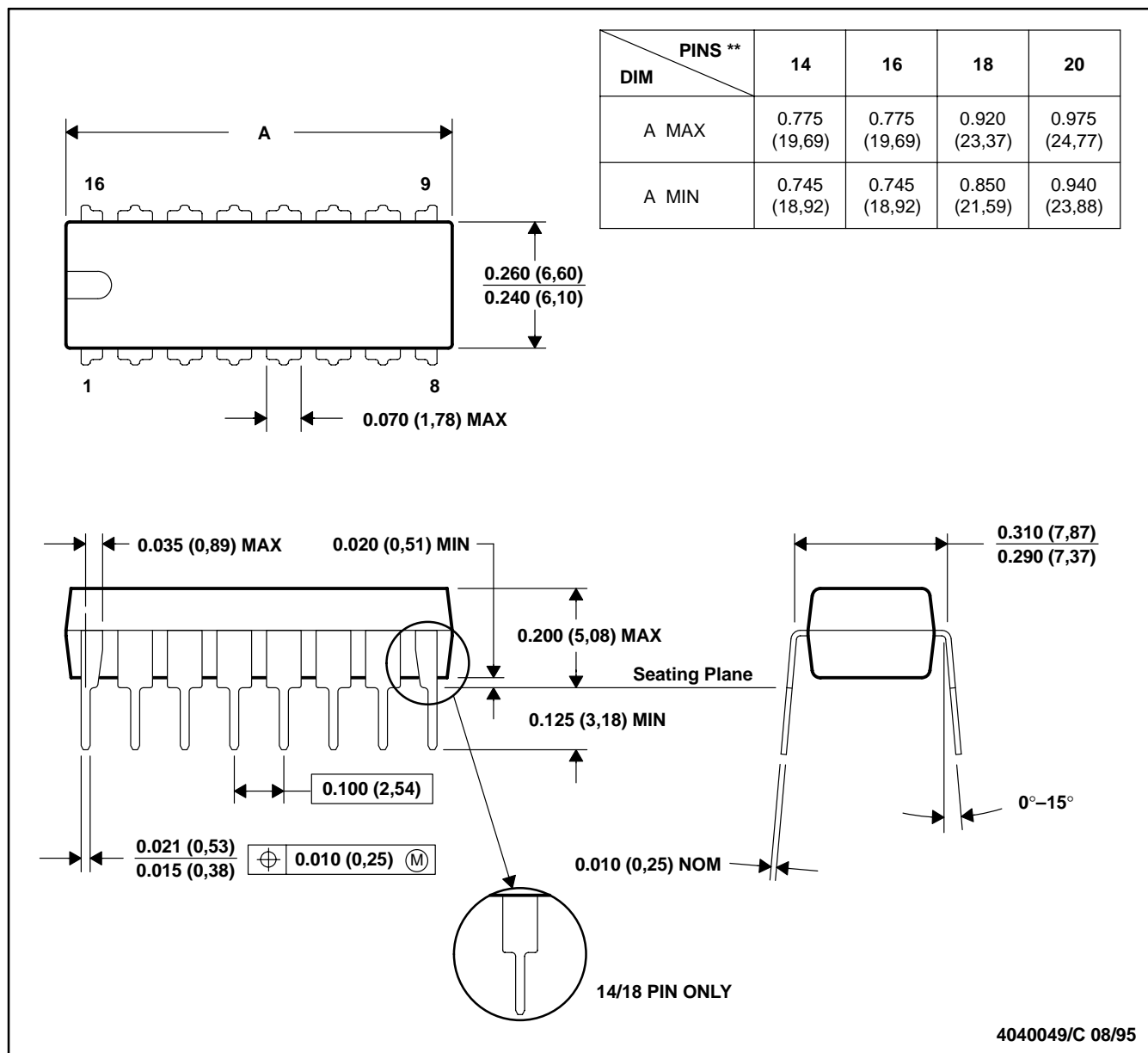
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MECHANICAL DATA

N (R-PDIP-T**)

PLASTIC DUAL-IN-LINE PACKAGE

16 PINS SHOWN



- NOTES: A. All linear dimensions are in inches (millimeters).
 B. This drawing is subject to change without notice.
 C. Falls within JEDEC MS-001 (20-pin package is shorter than MS-001).

TL1451A DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

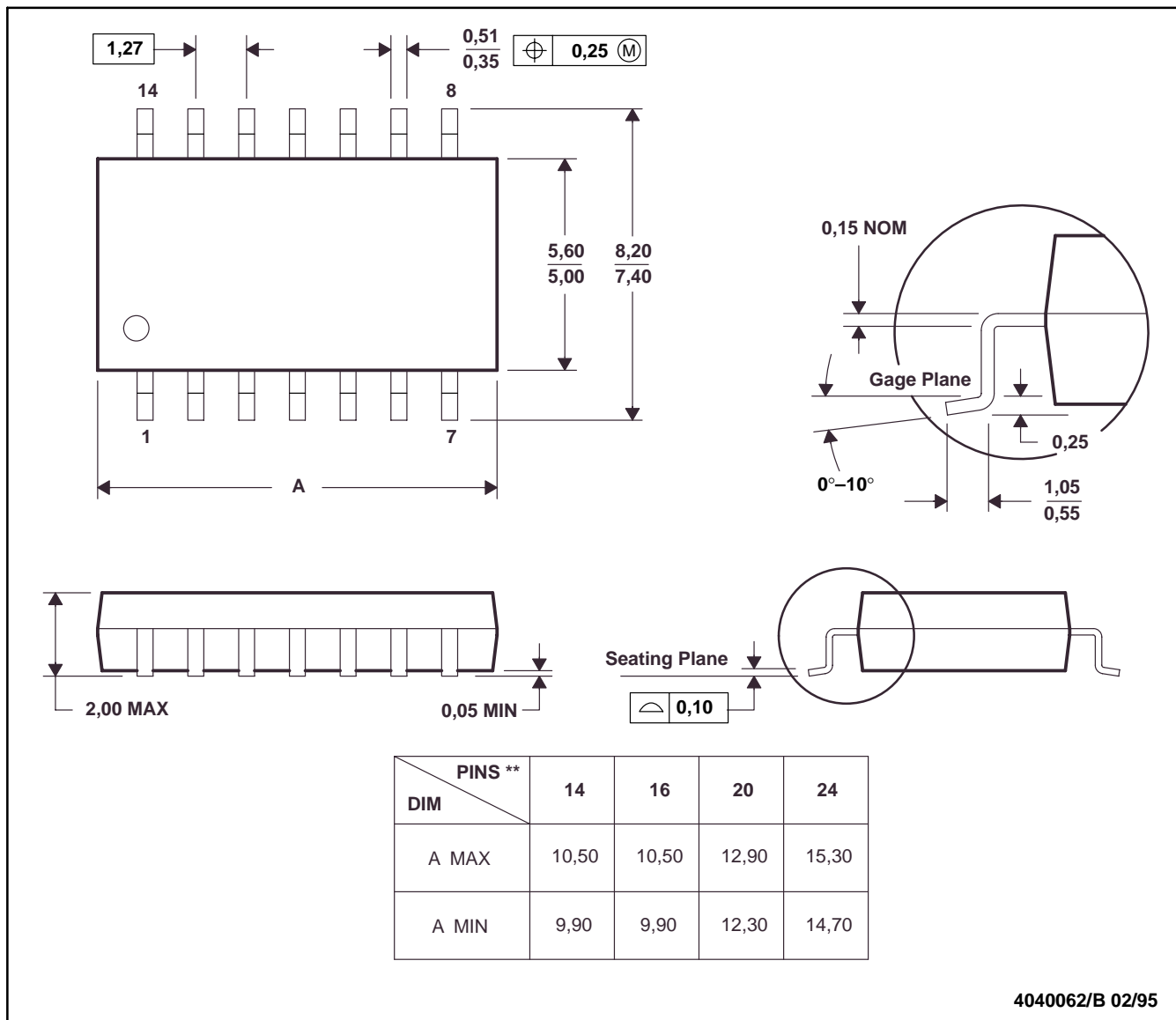
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MECHANICAL DATA

NS (R-PDSO-G)**

PLASTIC SMALL-OUTLINE PACKAGE

14 PINS SHOWN



- NOTES: A. All linear dimensions are in millimeters.
 B. This drawing is subject to change without notice.
 C. Body dimensions do not include mold flash or protrusion, not to exceed 0,15.

TL1451A DUAL PULSE-WIDTH-MODULATION CONTROL CIRCUITS

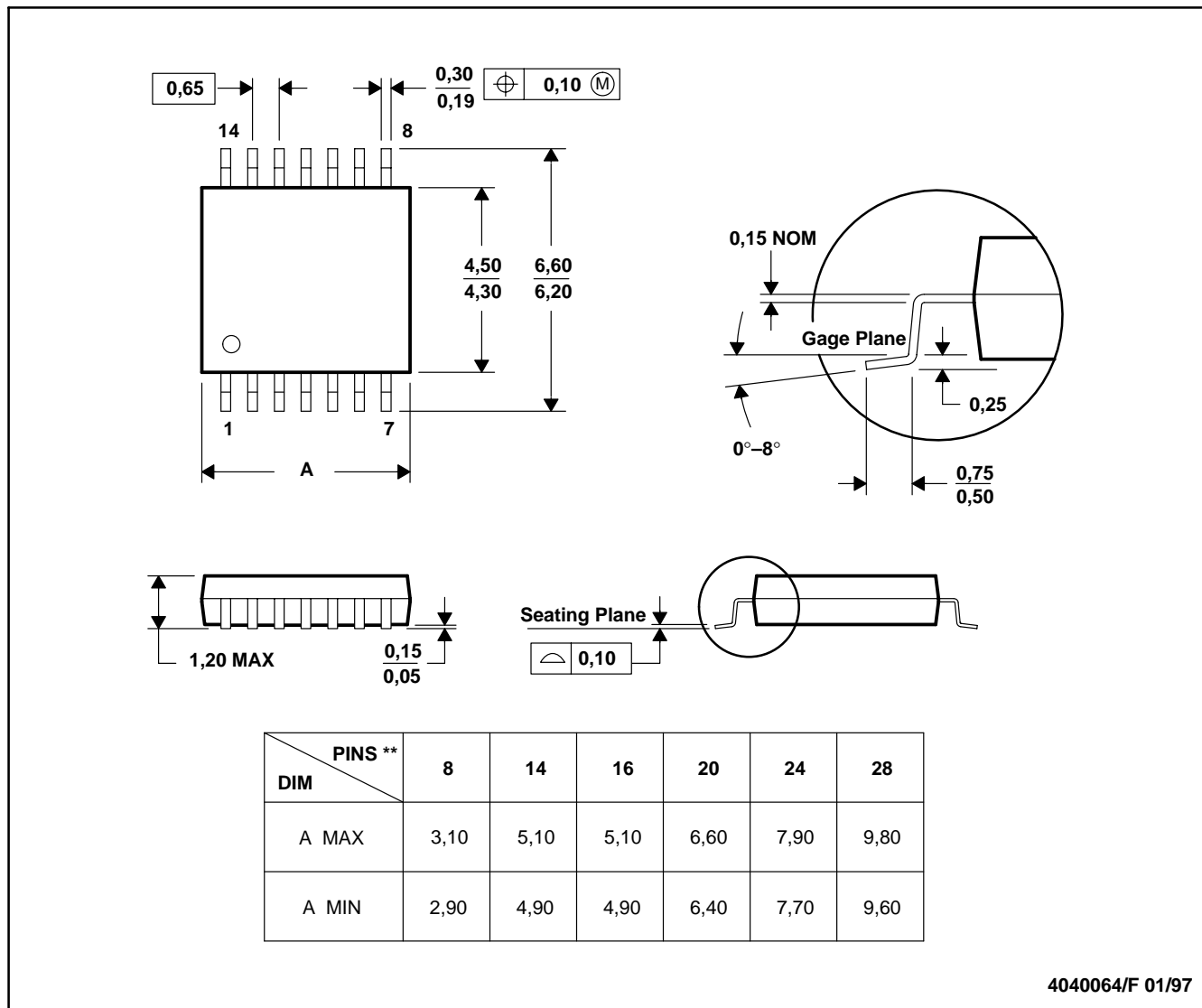
SLVS024E – FEBRUARY 1983 – REVISED NOVEMBER 1999

MECHANICAL DATA

PW (R-PDSO-G**)

PLASTIC SMALL-OUTLINE PACKAGE

14 PINS SHOWN



- NOTES: A. All linear dimensions are in millimeters.
 B. This drawing is subject to change without notice.
 C. Body dimensions do not include mold flash or protrusion not to exceed 0,15.
 D. Falls within JEDEC MO-153

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