

TL1466I HIGH-SPEED/PRECISION SIX CHANNEL SWITCHING REGULATOR CONTROLLER

SLVS262 – FEBRUARY 2000

- High-Speed Output Circuit to Drive PNP Power Transistor
- Precision Reference Voltage . . . 1.5 V $\pm 2\%$ at $T_A = 25^\circ\text{C}$
- Oscillator Frequency . . . 50 kHz to 0.8 MHz
- Low Supply Voltage Operation $V_{CC} = 2.5\text{ V}$ to 12 V
- Output Voltage Limit (Channel 5 and 6)
- Low Supply Current
- Internal Undervoltage Lockout Protection
- Internal Short-Circuit Protection
- Shutdown Function
- External Sink Current Setting on Output Stage

description

The TL1466I is a six channel pulse-width-modulation (PWM) control circuit. This device contains reference voltage with a precision of $\pm 2\%$, a triangle wave oscillator capable of high frequency oscillation up to 0.8 MHz, various protection circuitry, and shutdown circuitry. The output regulation voltage for each channel is set by an external resistor divider. Moreover, the output stage is capable of driving a PNP power transistor with high speed. The high frequency/efficiency switching operation eliminates switching loss by using internal over-drive circuitry at the rising edge and with reverse bias connecting external bootstrap capacitor at the falling edge. The MOSFET can be used in parallel with the output diode at channel 1 and 4. This results in further high efficiency operation replacing the constant time with this MOSFET when the output diode is turned on. Furthermore, it operates 2.5 V supply voltage and balances switching current by switching repeatedly at the reverse phase with two pairs (channel 1, 4, 6, and 2, 3, 5) of the six channels. The oscillator output of channel 1, 4, and 6 is reverse phase for channel 2, 3, and 5. As a result of these features, this device is well-suited for power supply of portable systems in battery-powered equipment.

FUNCTION TABLE FOR STANDBY

INPUT		OUTPUT		
STANDBY	STANDBY-3	VREF	OUTPUT1, 2, 4, 5, 6	OUTPUT3
$V_I \leq 0.4\text{ V}$	X [†]	OFF	OFF	OFF
$V_I \geq 2\text{ V}$	$V_I \geq 2\text{ V}$	ON	ON	ON
	$V_I \leq 0.4\text{ V}$	ON	ON	OFF

[†] X: High-level or low-level



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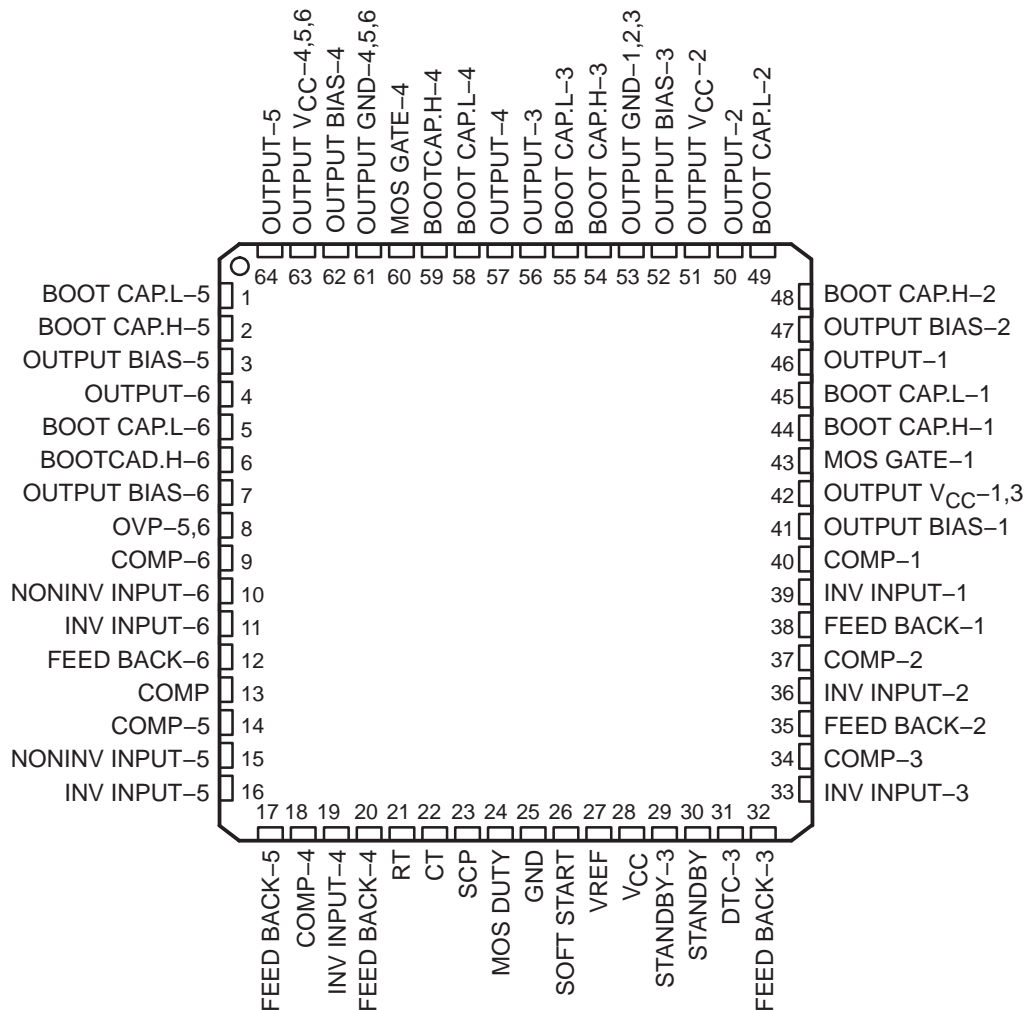
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pin assignments

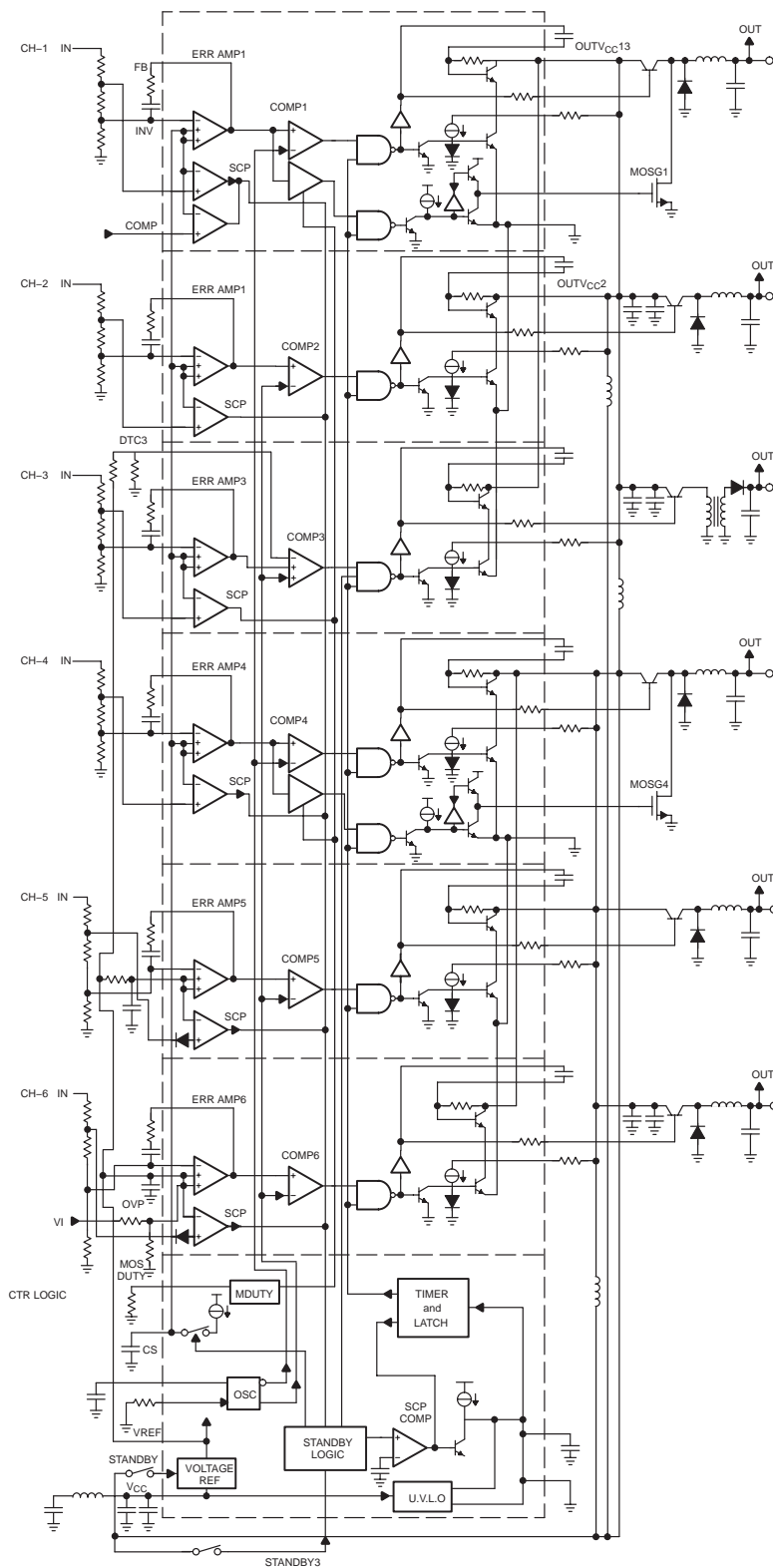
PM PACKAGE
(TOP VIEW)



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functional block diagram



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Terminal Functions

TERMINAL NAME	NO.	DESCRIPTION
BOOT CAP.H-1	44	Bootstrap capacitor connection. The connection allows reverse-bias for external PNP transistor of channel 1.
BOOT CAP.L-1	45	
BOOT CAP.H-2	48	Bootstrap capacitor connection. The connection allows reverse-bias for external PNP transistor of channel 2.
BOOT CAP.L-2	49	
BOOT CAP.H-3	54	Bootstrap capacitor connection. The connection allows reverse-bias for external PNP transistor of channel 3.
BOOT CAP.L-3	55	
BOOT CAP.L-4	58	Bootstrap capacitor connection. The connection allows reverse-bias for external PNP transistor of channel 4.
BOOT CAP.H-4	59	
BOOT CAP.L-5	1	Bootstrap capacitor connection. The connection allows reverse-bias for external PNP transistor of channel 5.
BOOT CAP.H-5	2	
BOOT CAP.L-6	5	Bootstrap capacitor connection. The connection allows reverse-bias for external PNP transistor of channel 6.
BOOT CAP.H-6	6	
COMP	13	Output regulation voltage monitor terminal. When this terminal voltage drops below VREF voltage (1.5 V), charging to capacitor connected to SCP terminal (pin 23) is initiated.
COMP-1	40	Output regulation voltage monitor terminal (channel 1). When this terminal voltage drops below VREF voltage (1.5 V) charging to capacitor connected to SCP terminal (pin 23) is initiated.
COMP-2	37	Output regulation voltage monitor terminal (channel 2). When this terminal voltage drops below VREF voltage (1.5 V) charging to capacitor connected to SCP terminal (pin 23) is initiated.
COMP-3	34	Output regulation voltage monitor terminal (channel 3). When this terminal voltage drops below VREF voltage (1.5 V), charging to capacitor connected to SCP terminal (pin 23) is initiated.
COMP-4	18	Output regulation voltage monitor terminal (channel 4). When this terminal voltage drops below VREF voltage (1.5 V) charging to capacitor connected to SCP terminal (pin 23) is initiated.
COMP-5	14	Output regulation voltage monitor terminal (channel 5). When this terminal voltage drops below NONINV INPUT-5 terminal voltage - 0.55 V, charging to capacitor connected to SCP terminal (pin 23) is initiated.
COMP-6	9	Output regulation voltage monitor terminal (channel 6). When this terminal voltage drops below NONINV INPUT-6 terminal voltage - 0.55 V, charging to capacitor connected to SCP terminal (pin 23) is initiated.
CT	22	Timing capacitor connection for oscillation frequency setting.
DTC-3	31	Dead-time control input for channel 3. The maximum ON duty cycle for OUTPUT-3 terminal is determined by comparing the input voltage of this terminal with the oscillator output (triangle wave).
FEEDBACK-1	38	Error amplifier output terminal (channel 1)
FEEDBACK-2	35	Error amplifier output terminal (channel 2)
FEEDBACK-3	32	Error amplifier output terminal (channel 3)
FEEDBACK-4	20	Error amplifier output terminal (channel 4)
FEEDBACK-5	17	Error amplifier output terminal (channel 5)
FEEDBACK-6	12	Error amplifier output terminal (channel 6)
GND	25	Logic ground
INV INPUT-1	39	Error amplifier inverting input terminal (channel 1)
INV INPUT-2	36	Error amplifier inverting input terminal (channel 2)
INV INPUT-3	33	Error amplifier inverting input terminal (channel 3)
INV INPUT-4	19	Error amplifier inverting input terminal (channel 4)
INV INPUT-5	16	Error amplifier inverting input terminal (channel 5)
INV INPUT-6	11	Error amplifier inverting input terminal (channel 6)
MOS DUTY	24	N-channel MOSFET ON duty cycle setting for the synchronous rectification of channel 1 and 4. The MOSFET ON duty cycle for the synchronous rectification is determined by the resistor value connected between this terminal and GND.



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Terminal Functions (Continued)

TERMINAL NAME	NO.	DESCRIPTION
MOS GATE–1	43	N-Channel MOSFET gate drive for the synchronous rectification of channel 1. The ON duty cycle for this terminal is determined by the resistor value connected to MOS DUTY (pin 24).
MOS GATE–4	60	N-Channel MOSFET gate drive for the synchronous rectification of channel 4. The ON duty cycle for this terminal is determined by the resistor value connected to MOS DUTY (pin 24).
NONINV INPUT–5	15	Error amplifier noninverting input terminal (channel 6). By connecting resistor and capacitor to this terminal, soft start function is accomplished increasing this terminal voltage slowly.
NONINV INPUT–6	10	Error amplifier noninverting input terminal (channel 6). By connecting resistor and capacitor to this terminal, soft start function is accomplished increasing this terminal voltage slowly.
OUTPUT–1	46	Output terminal to drive base for external PNP transistor of channel 1.
OUTPUT–2	50	Output terminal to drive base for external PNP transistor of channel 2.
OUTPUT–3	56	Output terminal to drive base for external PNP transistor of channel 3.
OUTPUT–4	57	Output terminal to drive base for external PNP transistor of channel 4.
OUTPUT–5	64	Output terminal to drive base for external PNP transistor of channel 5.
OUTPUT–6	4	Output terminal to drive base for external PNP transistor of channel 6.
OUTPUT BIAS–1	41	Resistor connection to set output sink current for OUTPUT–1 terminal (pin 46) of channel 1.
OUTPUT BIAS–2	47	Resistor connection to set output sink current for OUTPUT–2 terminal (pin 50) of channel 2.
OUTPUT BIAS–3	52	Resistor connection to set output sink current for OUTPUT–3 terminal (pin 56) of channel 3.
OUTPUT BIAS–4	62	Resistor connection to set output sink current for OUTPUT–4 terminal (pin 57) of channel 4.
OUTPUT BIAS–5	3	Resistor connection to set output sink current for OUTPUT–5 terminal (pin 64) of channel 5.
OUTPUT BIAS–6	7	Resistor connection to set output sink current for OUTPUT–6 terminal (pin 4) of channel 6.
OUTPUT GND–1,2,3	53	Ground for channel 1, 2, and 3 output.
OUTPUT GND–4,5,6	61	Ground for channel 4, 5, and 6 output.
OUTPUT V _{CC} –1,3	42	Supply voltage for channel 1 and 3 outputs.
OUTPUT V _{CC} –2	51	Supply voltage for channel 2 output.
OUTPUT V _{CC} –4,5,6	63	Supply voltage for channel 4, 5, and 6 outputs.
OVP–5,6	8	Over-voltage threshold voltage setting for output regulation voltage of channel 5 and 6.
RT	21	Timing resistor connection for oscillation frequency setting.
SCP	23	Capacitor connection for short-circuit protection. When voltage across COMP terminal for each channel is dropped below the specified threshold voltage, the capacitor connected between SCP and GND is charged by the constant current source (2.5 μ A Typ). If the voltage reaches to 1.5 V, the timer latch circuitry is set and all channel outputs are forced to turn off.
SOFT START	26	Soft start operation for channel 1 to 4. By connecting a capacitor between this terminal connected internally to error amplifier noninverting input for channel 1 to 4 and GND, soft start operation is enabled charging a capacitor with the constant current source (3 μ A Typ). Moreover, the same soft start operation is also enabled at the standby release using STANDBY–3 terminal only for channel 3.
STANDBY	30	ON/OFF common control input for all channels. The all channels output is turned off by adding low-level input voltage (0.4 V Max) to this terminal, and the reference voltage is also shutdown.
STANDBY–3	29	ON/OFF control input for channel 3. The channel 3 output is turned off by adding low-level input voltage (0.4 V Max) to this terminal.
V _{CC}	28	Supply voltage
VREF	27	1.5 V reference voltage output

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

Supply voltage, V_{CC} (see Note 1)	13 V
Input voltage, V_I at OVP, COMP	13 V
Error amplifier input voltage, $V_{(AMP)}$	13 V
Output voltage, V_O	13 V
Peak output sink current, $I_{(SINK)}$	100 mA
Peak output source current, $I_{(SOURCE)}$	-0.5 A
Continuous power total dissipation at (or below) 25°C free-air temperature (see Note 2)	1785 mW
Operating free-air temperature range, T_A	-20°C to 75°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.

- NOTES: 1. All voltages are with respect to GND.
2. Device mounted on a 50 mm × 1.6 mm, fFR4 printed-circuit board.

recommended operating conditions

	MIN	NOM	MAX	UNIT
Supply voltage, V_{CC}	2.5		12	V
High-level standby input voltage (pin 29, 30), $V_{I(HS)}$	2		V_{CC}	V
Low-level standby input voltage (pin 29, 30), $V_{I(LS)}$			0.4	V
Output voltage, V_O			12	V
Current into feedback terminal, I_{OAMP}	Channel 1, 4		-30	μA
	Channel 2, 3, 5, 6		-45	
Feedback capacitance, $C_{(NF)}$	0.5	5	100	nF
Bootstrap capacitance, $C_{(BOOT)}$	100	500		pF
Bias resistor, $R_{(BIAS)}$	3		20	kΩ
Timing resistor, $R_{(T)}$	12		100	kΩ
Timing capacitor, $C_{(T)}$	68		1000	pF
Oscillator frequency, $f_{(osc)}$	0.05		0.8	MHz
Operating free-air temperature, T_A	-20		75	°C

electrical characteristics over recommended operating free-air temperature range, $V_{CC} = 6 V$, $f = 0.43 MHz$ (unless otherwise noted)

reference section

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{ref} Output voltage (pin 27)	$T_A = 25^\circ C$, $I_{OR} = -1 mA$	1.47	1.50	1.53	V
$R_{(EGIN)}$ Line regulation	$V_{CC} = 2.5 V$ to 12 V, $I_{OR} = -1 mA$		2	12.5	mV
$R_{(EGL)}$ Load regulation	$I_{OL} = -0.1 mA$ to -1 mA		1	7.5	mV
$V_{(RTC1)}$ $V_{(RTC2)}$ Output voltage change with temperature	$T_A = -20^\circ C$ to 25°C		-0.2%	±2%	
	$T_A = 25^\circ C$ to 75°C		-0.2%	±2%	
I_{OS} Short-circuit output current	$V_{ref} = 0 V$	-4	-20		mA



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electrical characteristics over recommended operating free-air temperature range, $V_{CC} = 6\text{ V}$, $f = 0.43\text{ MHz}$ (unless otherwise noted) (continued)

undervoltage lockout section

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$V_{(th)}$	High-level threshold voltage	$T_A = 25^\circ\text{C}$		2.45		V
$V_{(tl)}$	Low-level threshold voltage			2.35		V
V_{hys}	Hysteresis		0.05	0.1		V
$V_{(R)}$	Reset threshold voltage (V_{CC})		2.1	2.2		V

oscillator section

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$f_{(OSC)}$	Oscillator frequency	$C_{(T)} = 100\text{ pF}$, $R_{(T)} = 47\text{ k}\Omega$		0.43		MHz
$f_{(dev)}$	Standard deviation of frequency	All the values are constant		7%		
$f_{(dv)}$	Frequency change with voltage	$V_{CC} = 2.5\text{ V to }12\text{ V}$		1%		
$f_{(dT1)}$	Frequency change with temperature	$T_A = -20^\circ\text{C to }25^\circ\text{C}$		-0.5%	$\pm 4\%$	
$f_{(dT2)}$		$T_A = 20^\circ\text{C to }75^\circ\text{C}$		0.5%	$\pm 4\%$	

output voltage monitor section

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$V_{(tOM)}$	Input threshold voltage (COMP terminals: pin 13, 18, 34, 37, 40)	$T_A = 25^\circ\text{C}$ (channel 1, 2, 3, 4)	1.45	1.50	1.55	V
$V_{(IOOM)}$	Input offset voltage (pin 9, 14)	$V_I(10, 15\text{ pin}) = 1.5\text{ V}$, $T_A = 25^\circ\text{C}$ (channel 5,6)		0.55		V
$I_{(ICOMP)}$	Input bias current	Pin 13, 18, 34, 37, 40		-0.8	-2	μA
		Pin 9, 14	$V_I = 0.5\text{ V}$, $V_I(10, 15\text{ pin}) = 1.5\text{ V}$			

short-circuit protection control section

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$V_{(tPC)}$	Input threshold voltage (pin 23)	$T_A = 25^\circ\text{C}$	1.45	1.53	1.61	V
$V_{(STBY)}$	UVLO standby voltage (pin 23)		20	60	100	mV
V_I	Latched input voltage (pin 23)			10	30	mV
$I_{(bPC)}$	Input source current (pin 23)	$T_A = 25^\circ\text{C}$	-1	-2.5	-3.5	μA

dead-time control section (channel 3)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$I_{(Idt)}$	Input current (DTC-3 terminal: pin 31)	$V_I(31\text{ pin}) = 0.5\text{ V}$		-1	-6	μA
$V_{(t)}$	Input threshold voltage	Duty cycle = 0%	0.55	0.65	0.75	V
$V_{(t100)}$		Duty cycle = 100%	1.25	1.35	1.45	

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electrical characteristics over recommended operating free-air temperature range, $V_{CC} = 6\text{ V}$, $f = 0.43\text{ MHz}$ (unless otherwise noted) (continued)

error-amplifier section

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT	
$V_{(t)}$ Input threshold voltage	$V_O = 1\text{ V}$ (channel 1, 2, 3, 4)	1.46	1.50	1.54	V	
V_{IO} Input offset current	$V_O = 1\text{ V}$ (channel 5, 6)		5	40	mV	
I_{IB} Input bias current	$V_O = 1\text{ V}$	INV INPUT (pin 11, 16, 19, 33, 36, 39)		-200	-500	nA
		INV INPUT (pin 10, 15)		-0.9	-2.5	μA
V_{ICR} Common-mode input voltage range	$V_{CC} = 2.5\text{ V}$ to 12 V	0 to $V_{CC}-1$			V	
$A_{(v)}$ Open-loop voltage amplification		70			dB	
B1 Unity-gain bandwidth		6			MHz	
V_{OM+} Positive output voltage swing		$V_{ref}-0.1$			V	
V_{OM-} Negative output voltage swing		0.2			V	
I_{OM+} Output sink current	$V_O = 1\text{ V}$	0.5	2		mA	
I_{OM-} Output source current	$V_O = 1\text{ V}$	Channel 1, 4		-30	-80	μA
		Channel 2, 3, 5, 6		-45	-100	

output voltage limit section (channel 5, 6)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
$V_{(tOV)}$ Input threshold voltage	$V_{I(10, 15\text{ pin})} = 1\text{ V}$	0.95	1	1.05	V
$V_{(BOV)}$ Input bias current	$V_{I(8\text{ pin})} = 1.5\text{ V}$, $V_{I(10, 15\text{ pin})} = 1\text{ V}$	-0.7		-2	μA

soft start section

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
$I_{(bss)}$ Input source current (pin 26)	STANDBY-3 terminal = 2 V SOFT START terminal = 1 V	-1	-2.5	-4	μA

MOSFET DUTY setting section (channel 1, 4)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
$D_{(MOS)}$ ON DUTY	$V_{(FB)} = 1\text{ V}$	$R_{DUTY} = 5\text{ k}\Omega$		20%	
		$R_{DUTY} = 25\text{ k}\Omega$		40%	

output section

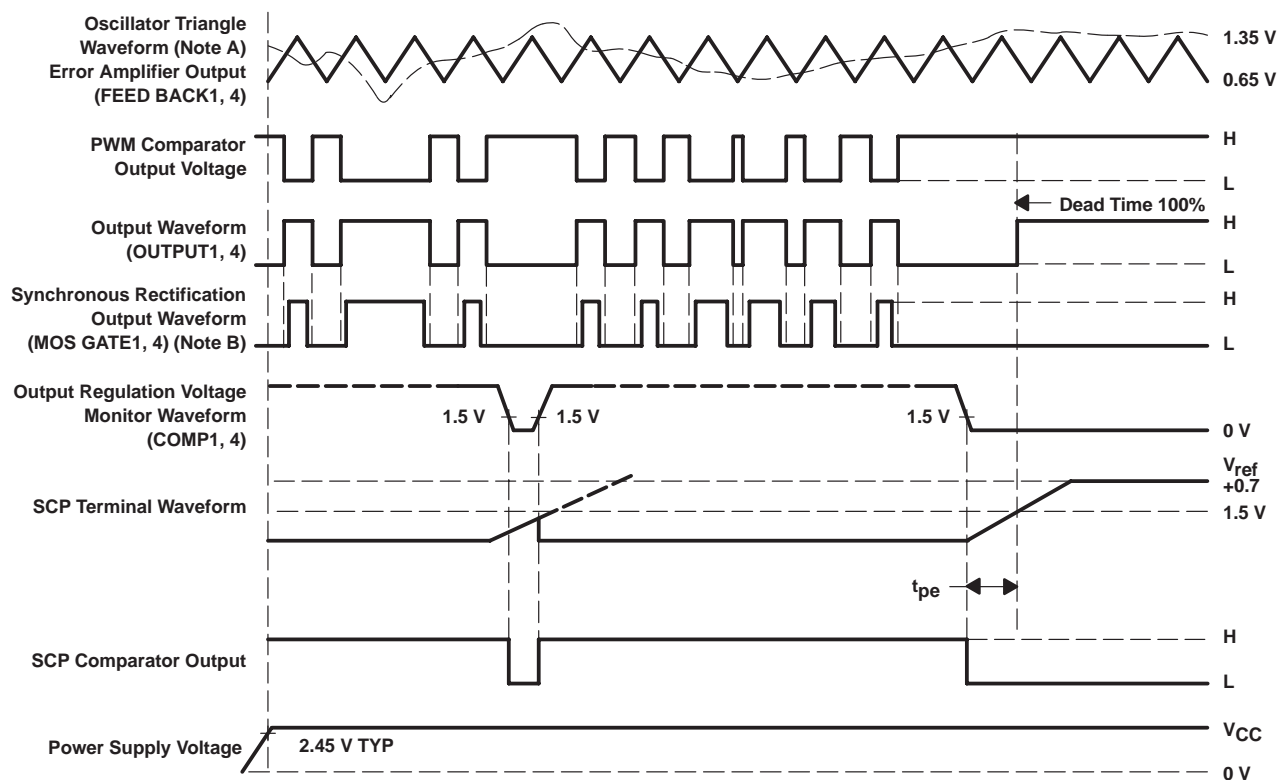
PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
$I_{(SINK)}$ Output sink current	$R_{(BIAS)} = 6.8\text{ k}\Omega$	6.3	8.5	10.7	mA
	$R_{(BIAS)} = 10\text{ k}\Omega$	4.5	6	7.5	
$I_{(GSOURCE)}$ MOS gate source current	$V_O(43, 60\text{ pin}) = 1\text{ V}$, $T_A = 25^\circ\text{C}$		-50		mA
$I_{(GSINK)}$ MOS gate sink current	$V_O(43, 60\text{ pin}) = 2\text{ V}$, $T_A = 25^\circ\text{C}$		50		mA
$I_{(GOH)}$ MOS gate high-level output voltage		3.5	4		V
$I_{(GOL)}$ MOS gate low-level output voltage			0.1	0.3	

total device

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
$I_{(ccs)}$ Standby supply current	STANDBY terminal = 0 V		1	10	μA
$I_{(cca)}$ Average supply current	$R_{(T)} = 47\text{ k}\Omega$		6	9	mA



PARAMETER MEASUREMENT INFORMATION



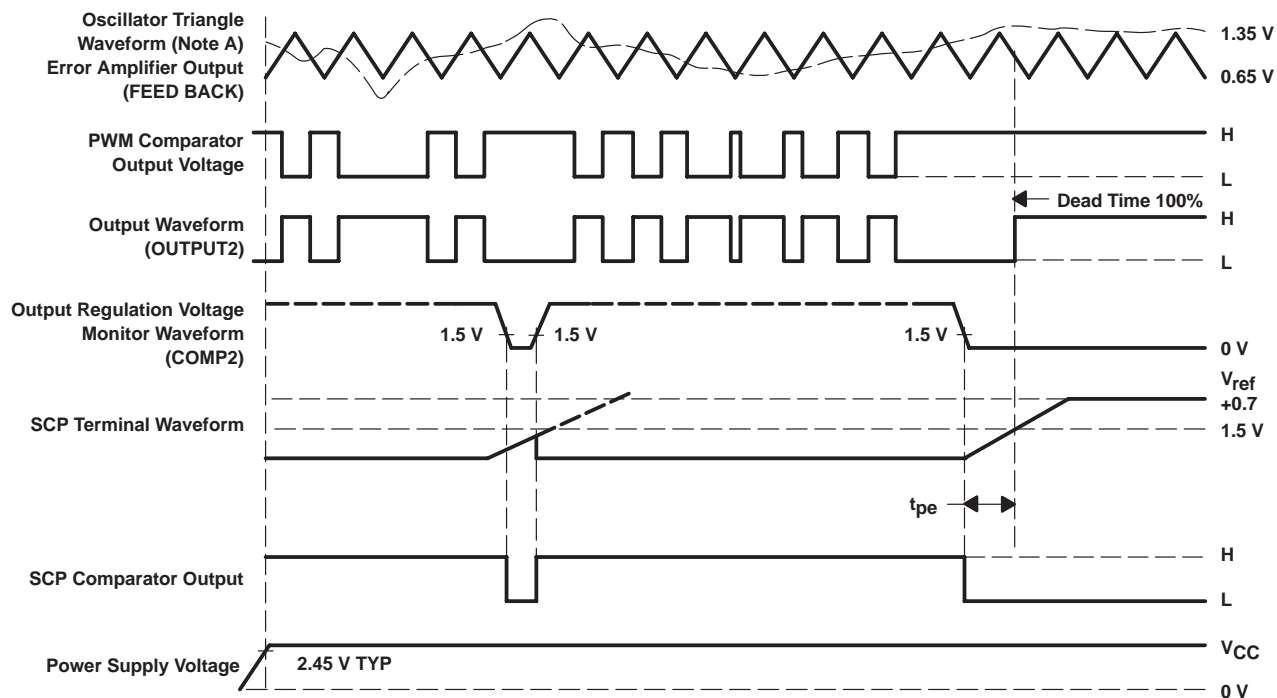
† Protection enable time, $t_{pe} = (588 \times 10^3 \times C_{pe})$ in seconds

NOTES: A. The oscillator output of channel 1, 4, and 6 is reverse phase for channel 2, 3, and 5.

B. The ON (high-level output state) time for the synchronous rectification output (MOS GATE1, 4) is determined by the resistor value connected to MOS DUTY terminal (pin 24) and this time is controlled internally without exceeding OFF (high-level output state) of output (OUTPUT1,4).

Figure 1. Timing Diagram (channel 1, 4)

PARAMETER MEASUREMENT INFORMATION

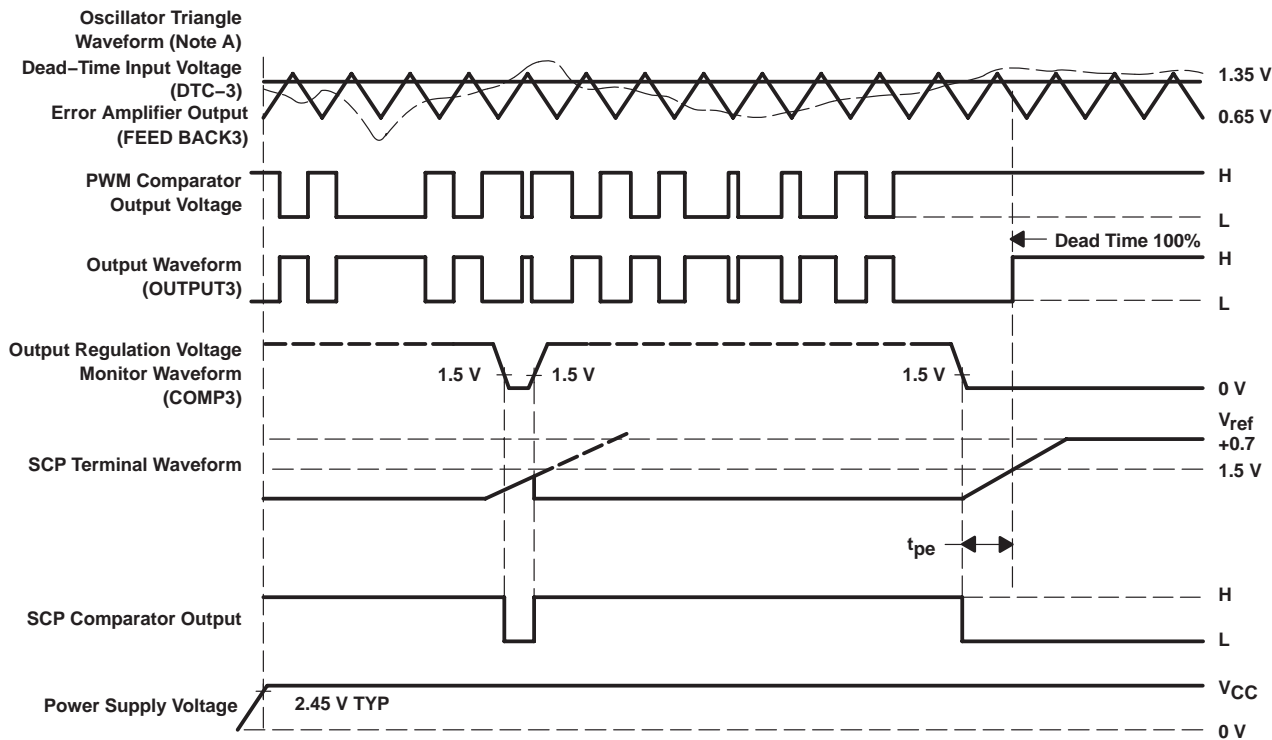


† Protection enable time, $t_{pe} = (588 \times 10^3 \times C_{pe})$ in seconds

NOTE A: The oscillator output of channel 1, 4, and 6 is reverse phase for channel 2, 3, and 5.

Figure 2. Timing Diagram (channel 2)

PARAMETER MEASUREMENT INFORMATION



† Protection enable time, $t_{pe} = (588 \times 10^3 \times C_{pe})$ in seconds

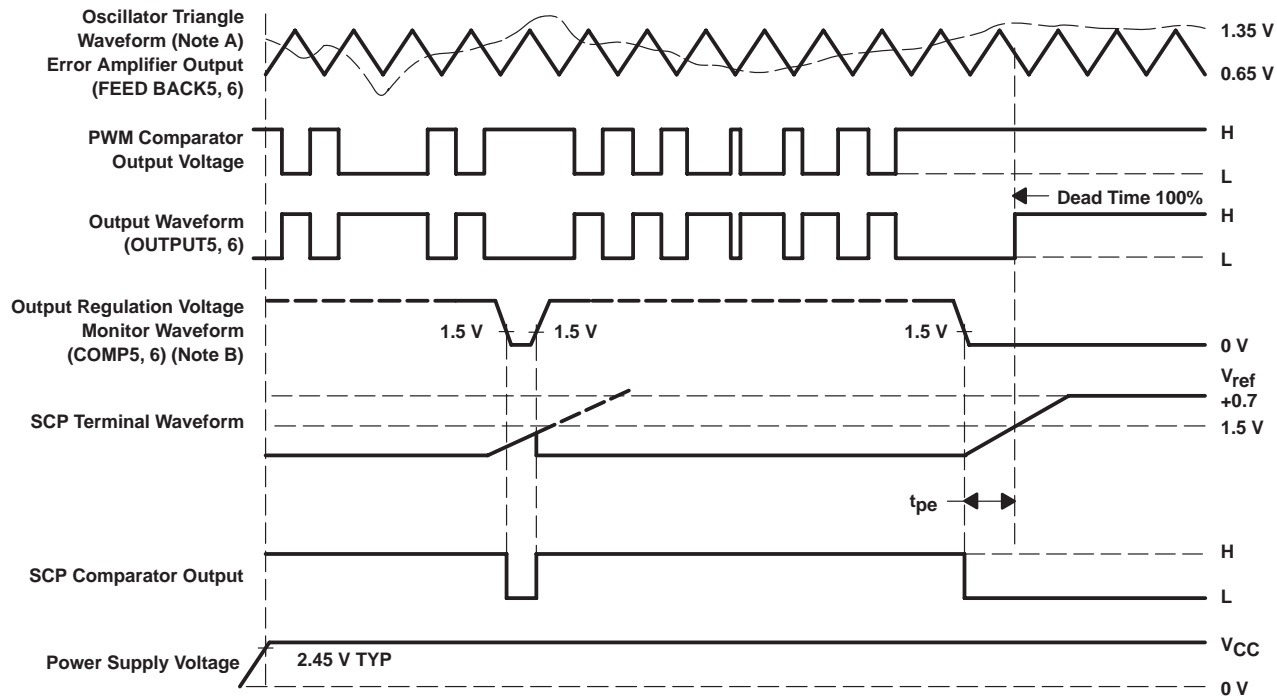
NOTE A: The oscillator output of channel 1, 4, and 6 is reverse phase for channel 2, 3, and 5.

Figure 3. Timing Diagram (channel 3)

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PARAMETER MEASUREMENT INFORMATION



† Protection enable time, $t_{pe} = (588 \times 10^3 \times C_{pe})$ in seconds

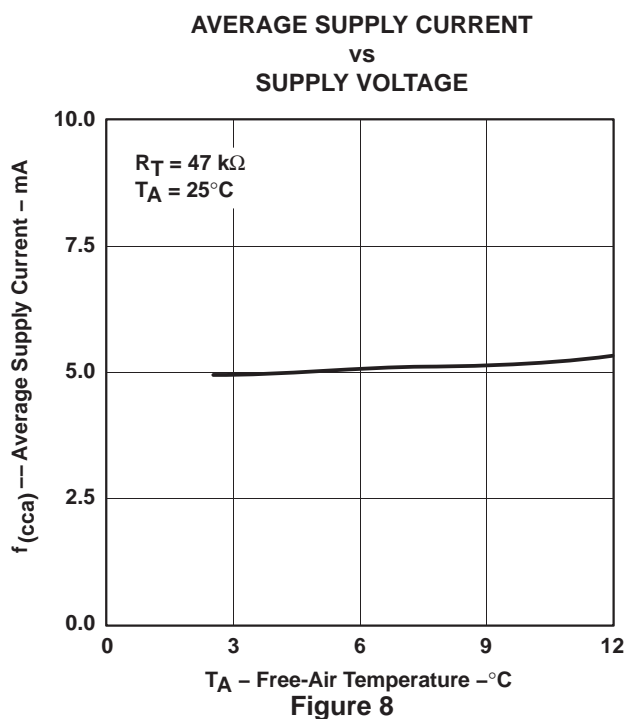
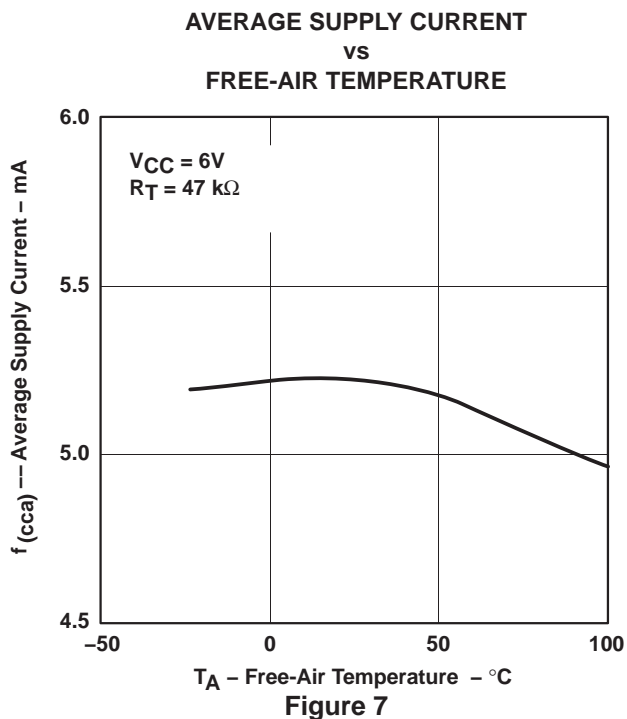
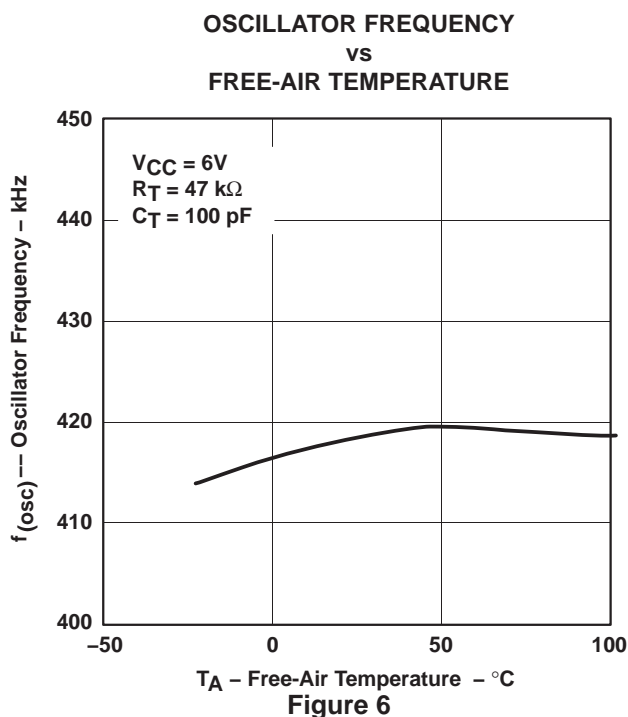
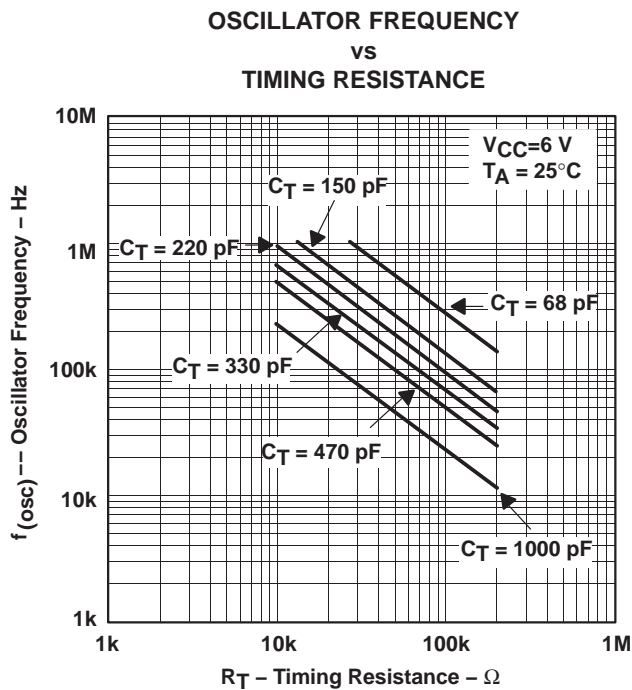
NOTES: A. The oscillator output of channel 1, 4, and 6 is reverse phase for channel 2, 3, and 5.

B. The threshold voltage at $V_{(A)}$ is set by following the formula below:

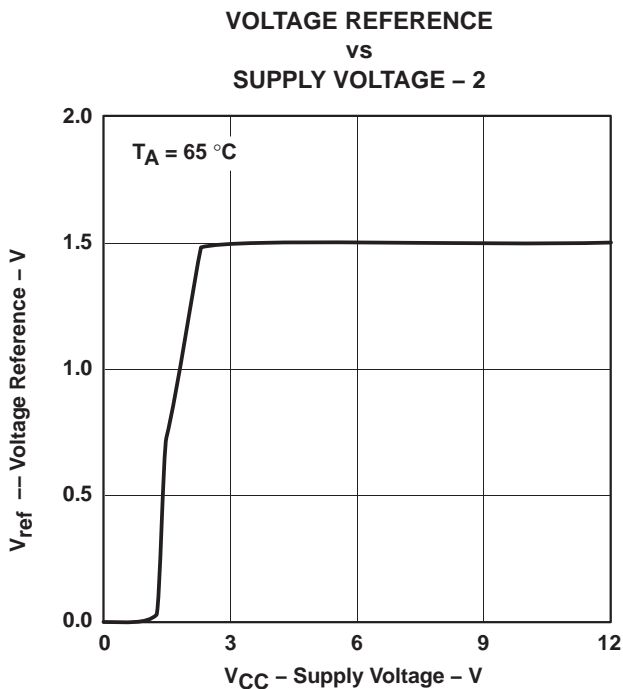
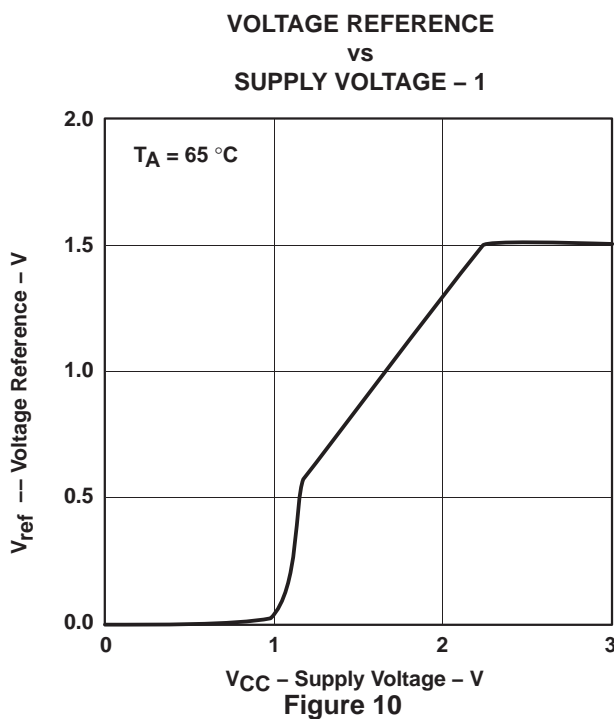
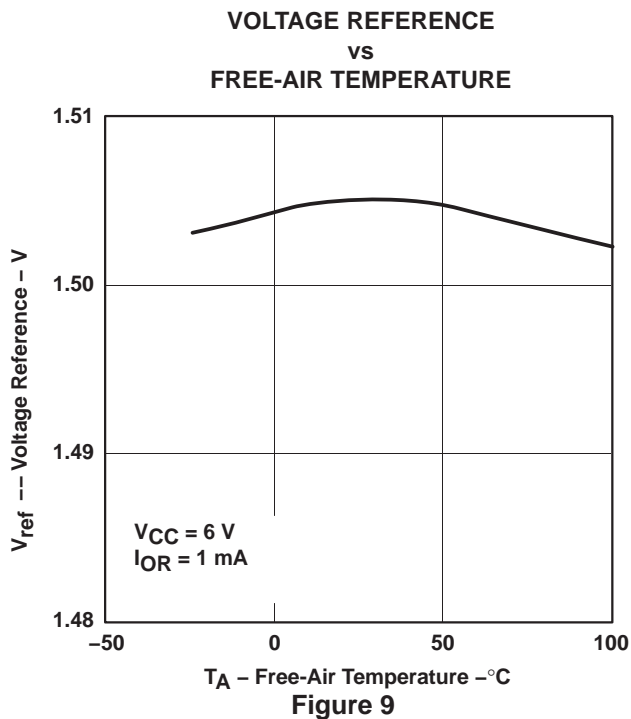
$V_{(A)}$ Input voltage of NONINV INPUT terminal (pin 10, 15) -0.55 V

Figure 4. Timing Diagram (channel 5, 6)

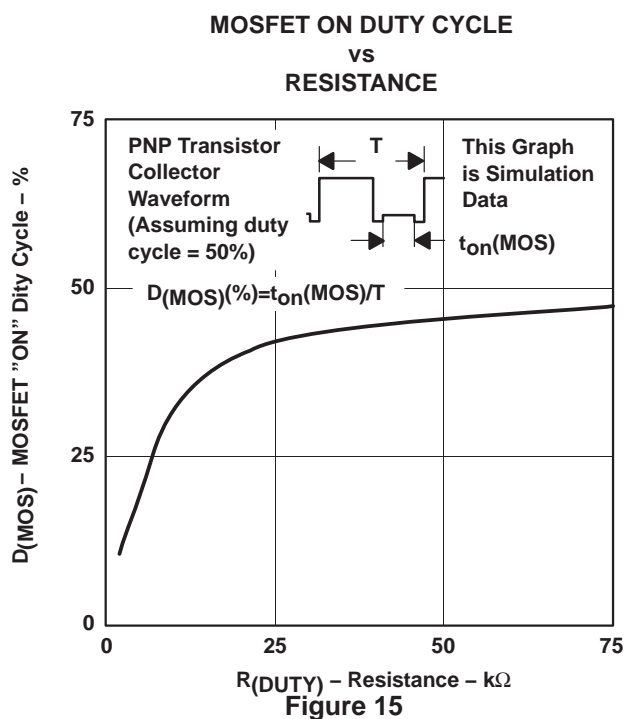
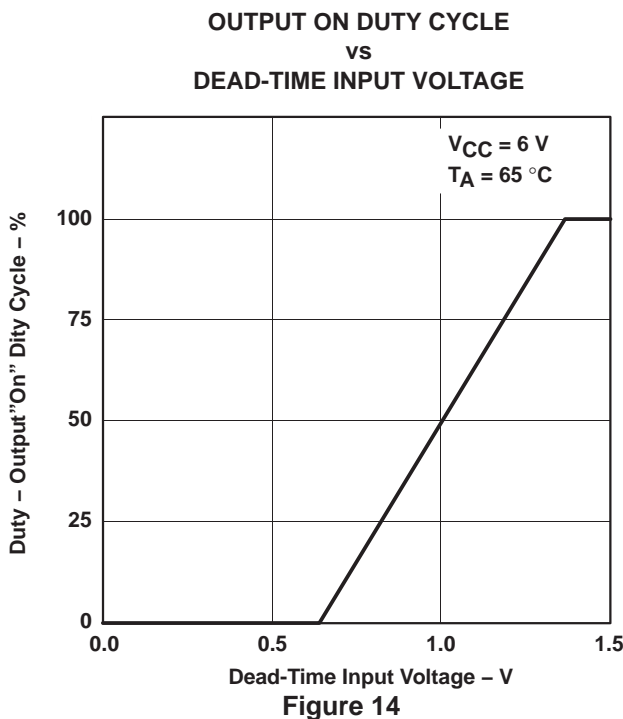
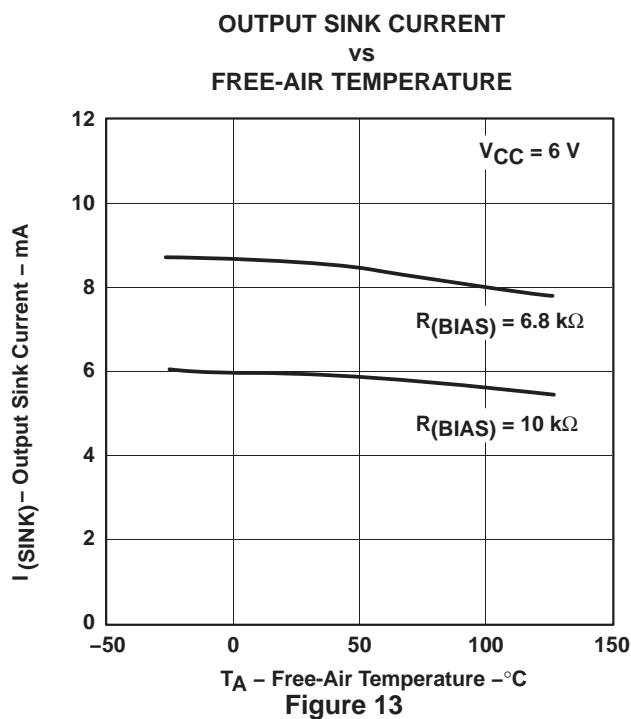
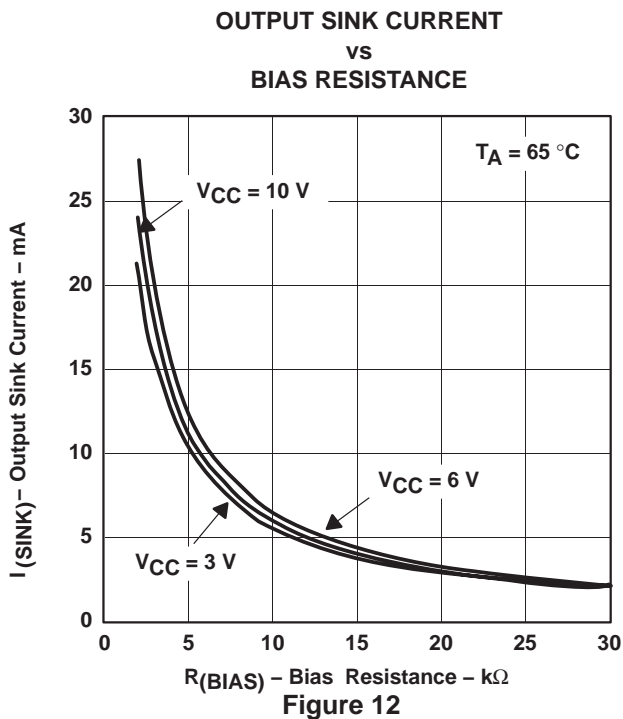
TYPICAL CHARACTERISTICS



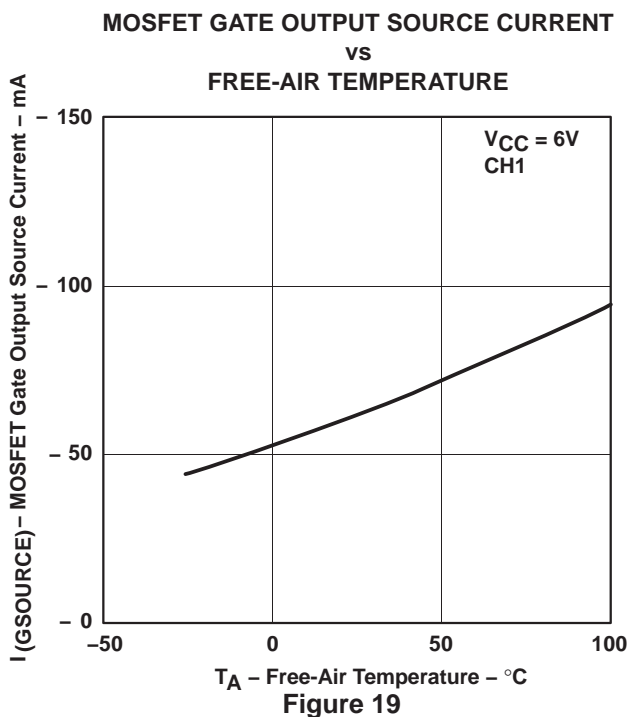
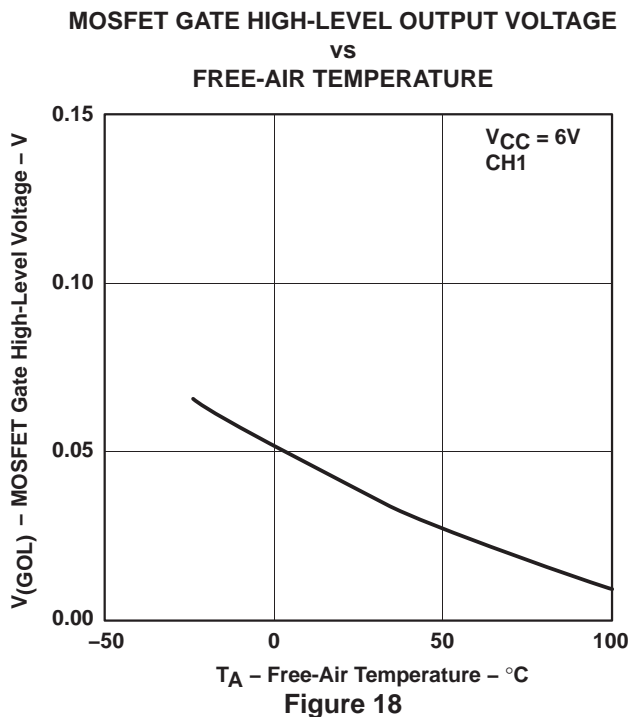
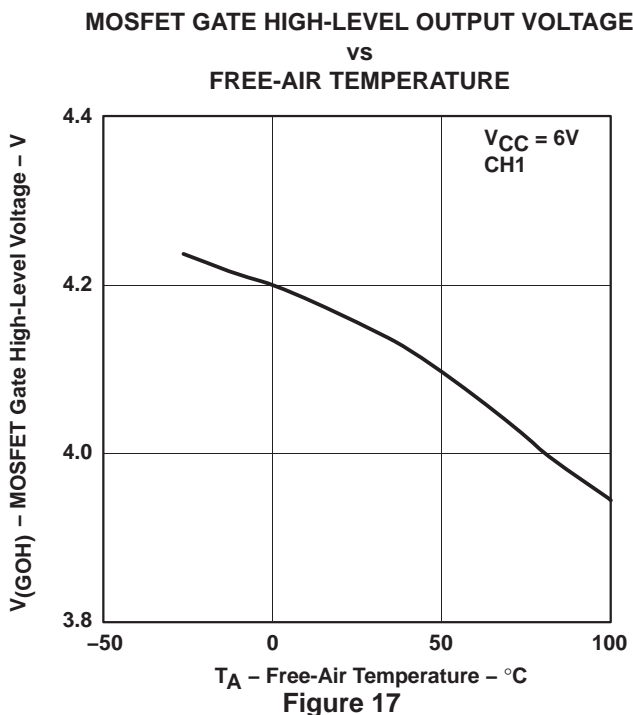
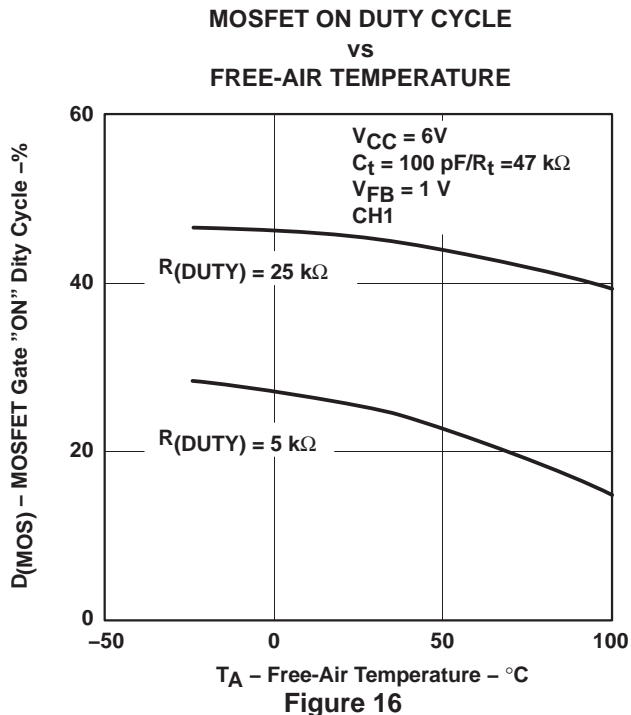
TYPICAL CHARACTERISTICS



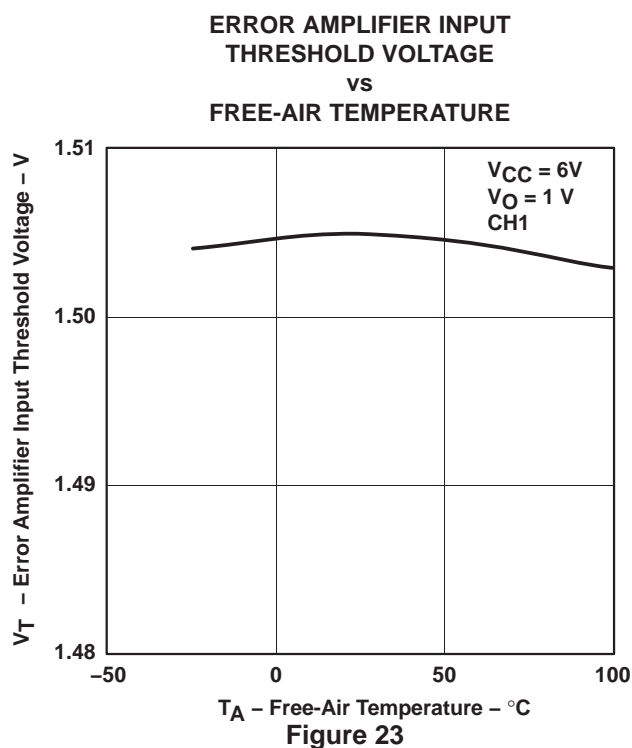
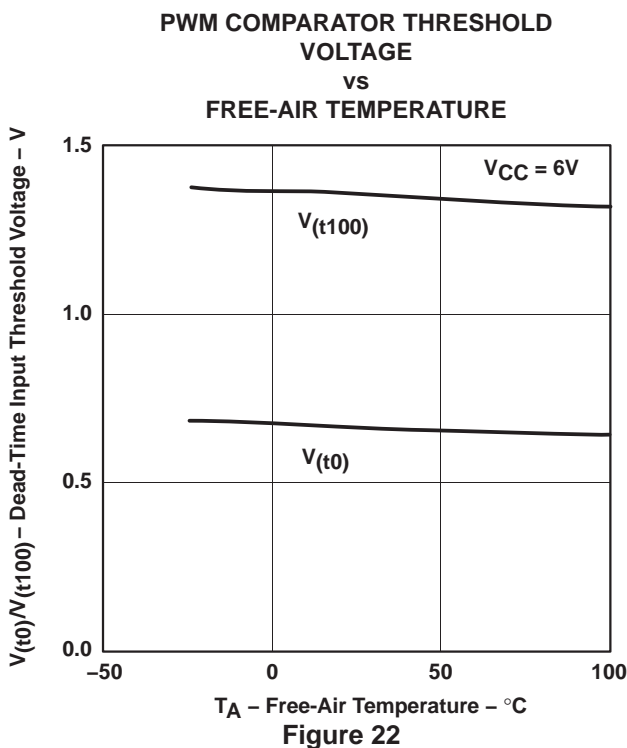
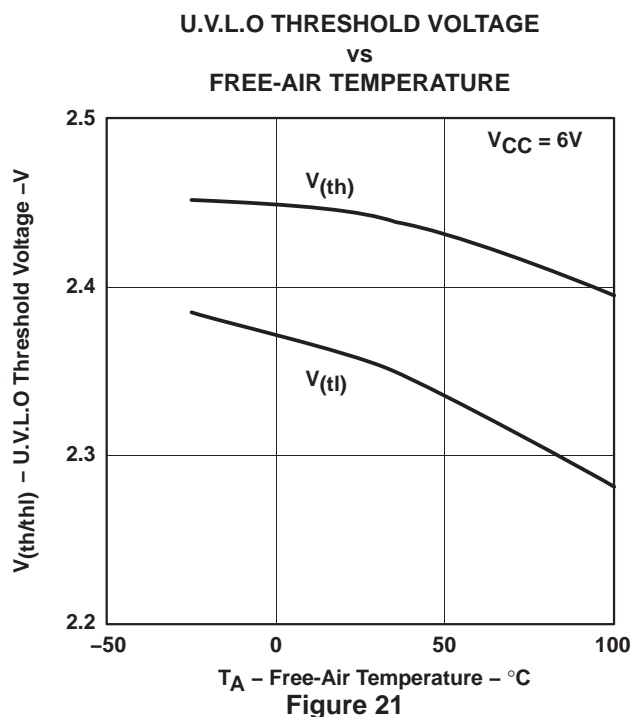
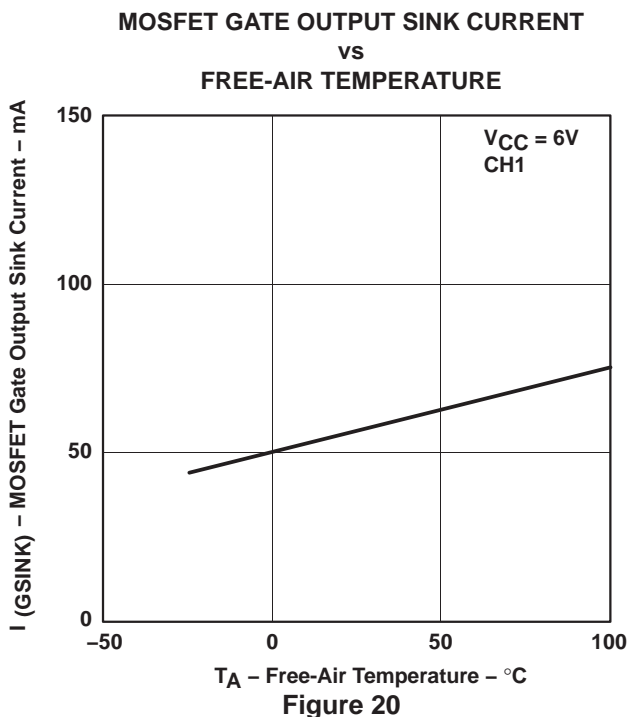
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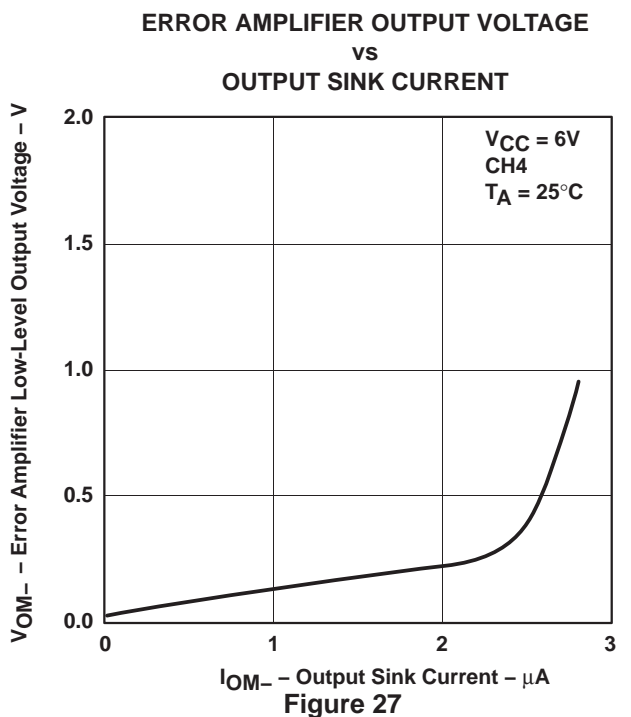
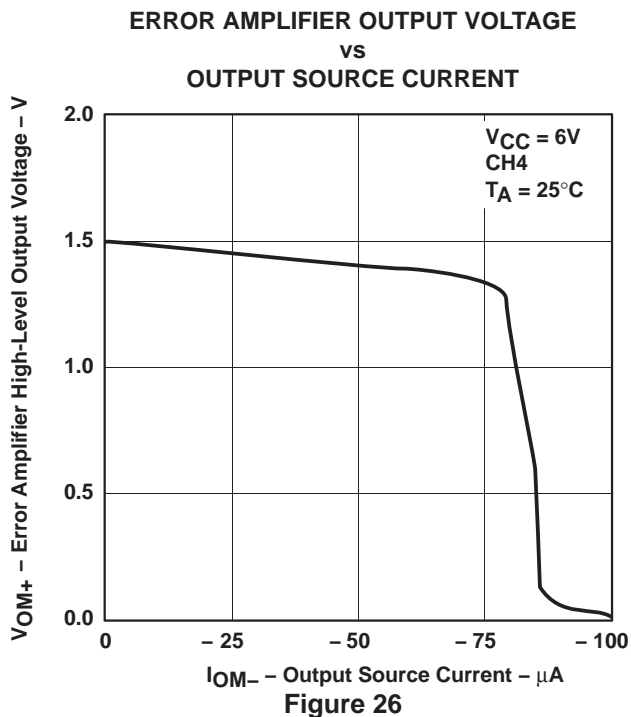
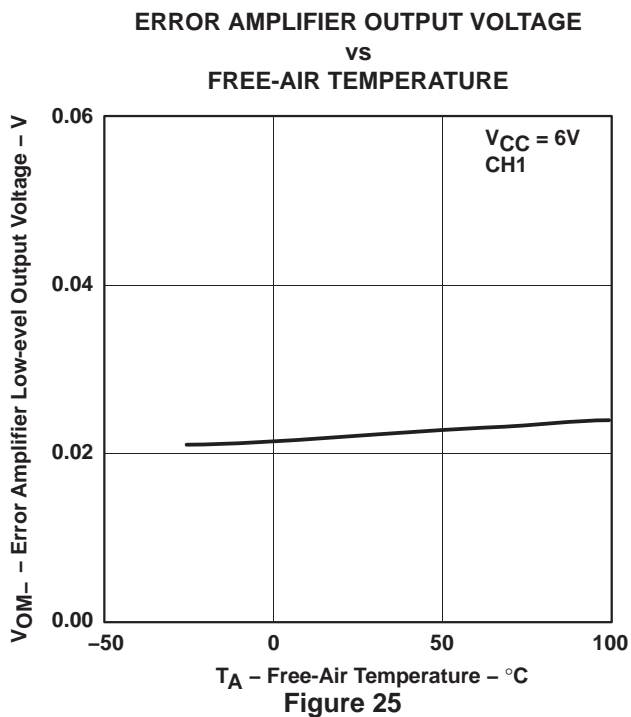
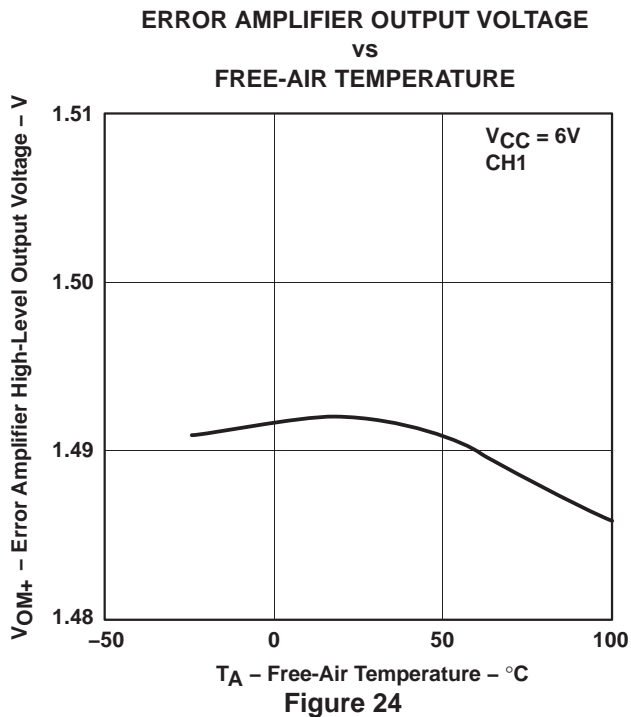
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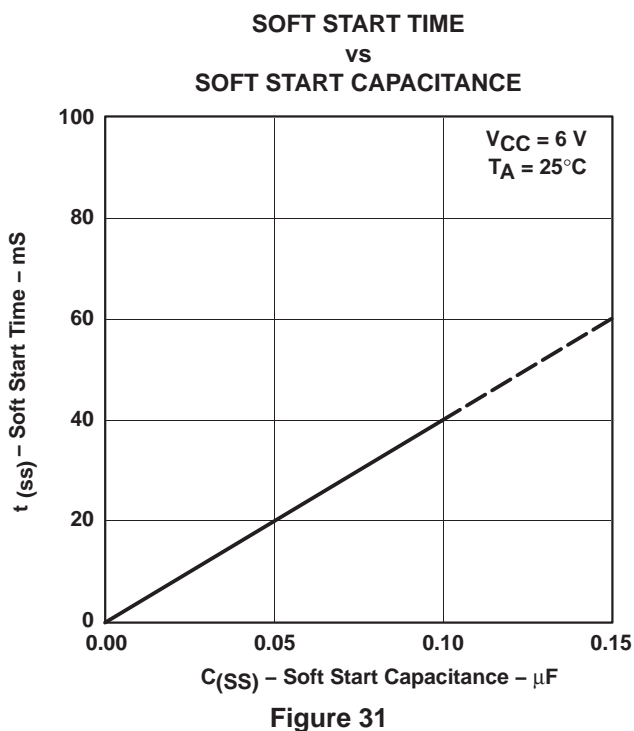
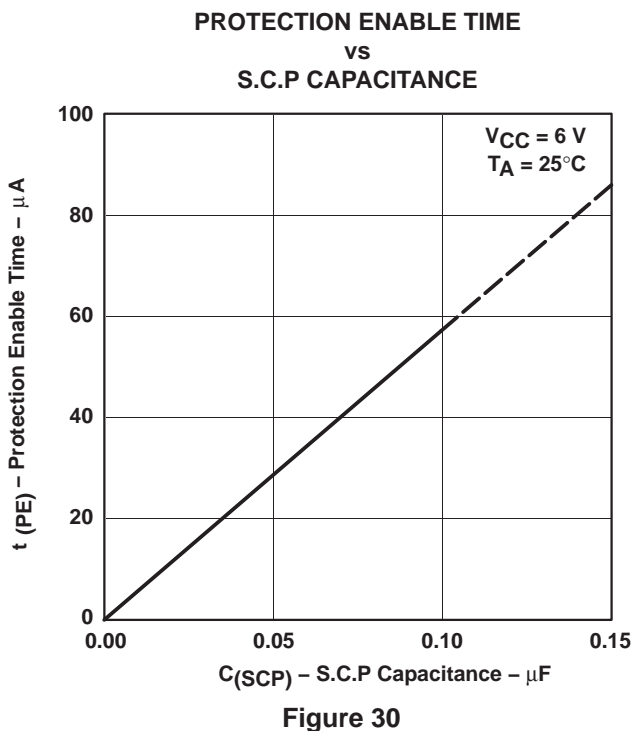
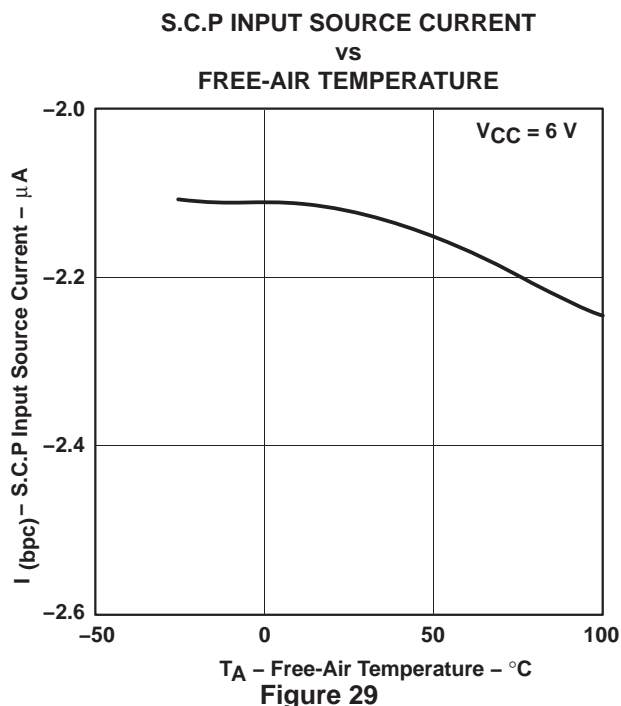
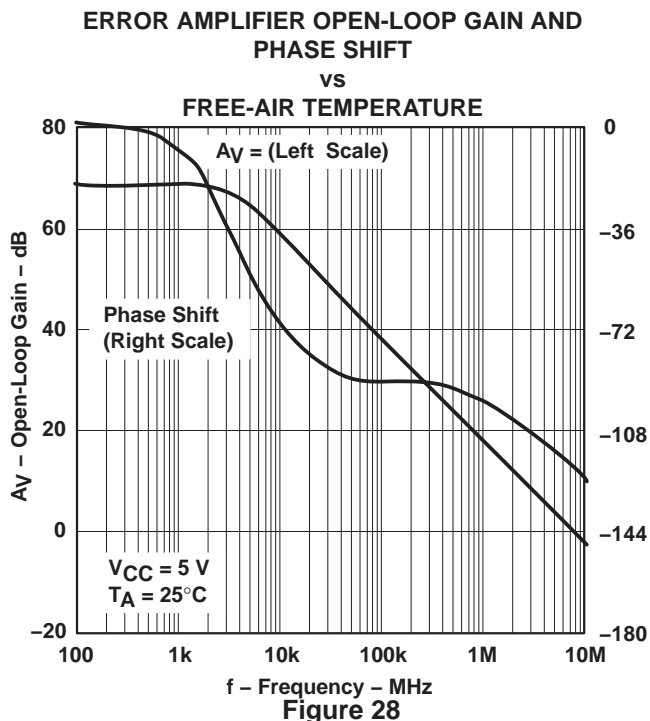
TYPICAL CHARACTERISTICS



TYPICAL CHARACTERISTICS



TYPICAL CHARACTERISTICS



TL1466I HIGH-SPEED/PRECISION SIX CHANNEL SWITCHING REGULATOR CONTROLLER

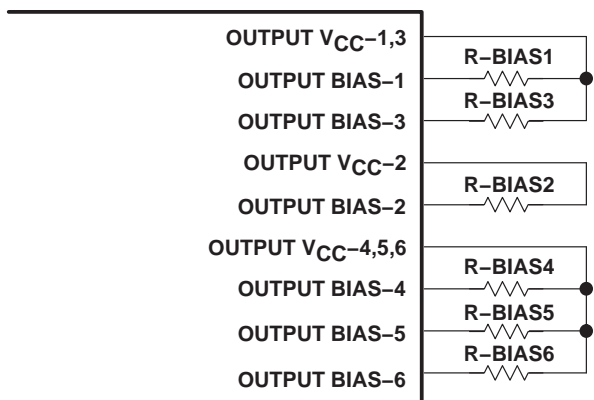
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APPLICATION INFORMATION

bias resistance connection for output sink current setting

The bias resistance connection to set output sink current for each output of channel 1 through 6 (OUTPUT-1 to 6) should be connected as follows (refer to Figure 32):

- For channel 1 and 3, connect OUTPUT BIAS to OUTPUT $V_{CC-1,3}$ across bias resistance.
- For channel 2, connect OUTPUT BIAS-2 to OUTPUT V_{CC-2} across bias resistance
- For channel 4, 5, and 6, connect OUTPUT BIAS to OUTPUT $V_{CC-4,5,6}$ across bias resistance.



TL1466IPM

Figure 32. Bias Resistance Connection for Output Sink Current Setting

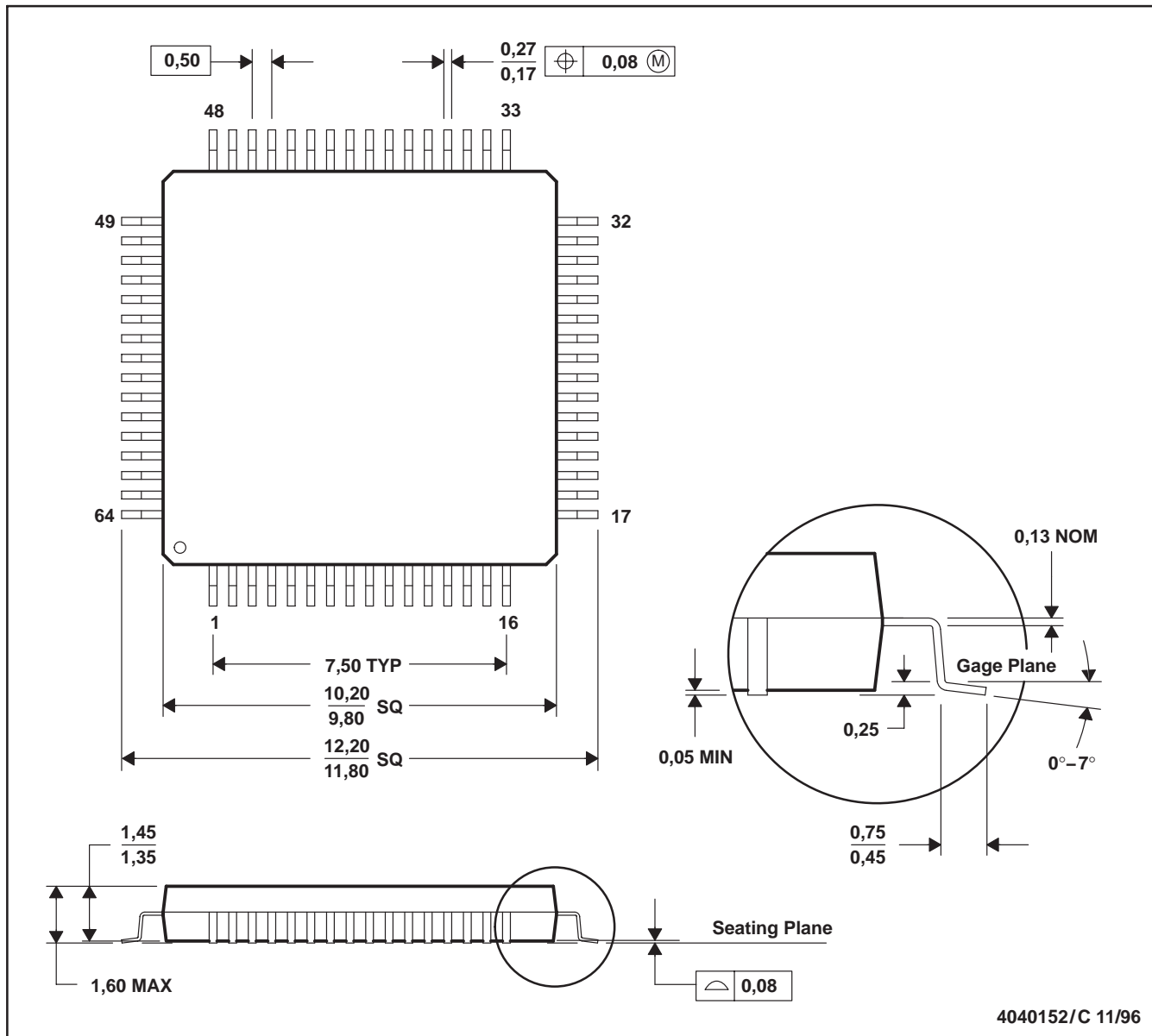
TL1466I
HIGH-SPEED/PRECISION SIX CHANNEL
SWITCHING REGULATOR CONTROLLER

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MECHANICAL DATA

PM (S-PQFP-G64)

PLASTIC QUAD FLATPACK



- NOTES: A. All linear dimensions are in millimeters.
 B. This drawing is subject to change without notice.
 C. Falls within JEDEC MS-026
 D. May also be thermally enhanced plastic with leads connected to the die pads.

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