

STEP-UP/STEP-DOWN PWM DC/DC CONVERTER WITH VOLTAGE DETECTOR

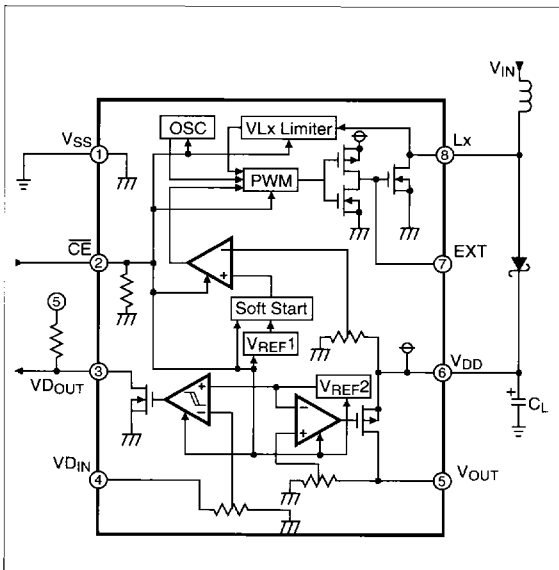
FEATURES

- Low quiescent current typ 50 μ A (TC151A/1B3624; $V_{IN} = 3.0V$, No Load)
- Low standby current 1A version 1.0 μ A MAX
1B version 10.0 μ A MAX
- Low voltage operation $V_{IN} = 1.2$ to 10V
- High accuracy output voltage $\pm 2.5\%$
- Wide choice of V_{OUT} 1.5V to 6.0V in 0.1V Steps
- Wide choice of V_{DET} 1.2V to 5.0V in 0.1V Steps
- Soft start and driver protection circuit
- Phase compensation circuit
- Small package 8-Pin SOIC
- Larger current can be obtained by connecting an external power transistor

APPLICATIONS

- Laptop computers
- Portable equipment
- Pagers, cellular and cordless telephones
- Cameras and hand-held systems

FUNCTIONAL BLOCK DIAGRAM



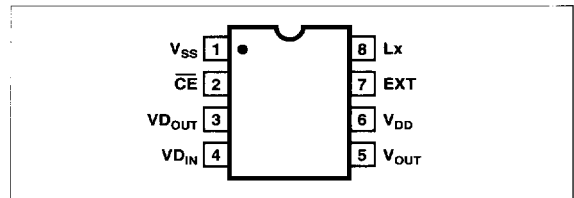
GENERAL DESCRIPTION

The TC15 Series are CMOS power-supply ICs containing a low-dropout linear regulator, an under-voltage detector, and a PWM DC/DC step-up (boost) converter. In normal operation (V_{IN} well above V_{OUT}), the device functions as a linear regulator. When V_{IN} drops below $V_{IN}(\text{min.})$ or less, the voltage detector (V_{DET}) senses this and turns on the boost converter that raises V_{IN} back up to the linear regulator's operating range. The TC15 thus extends battery life considerably by allowing the battery voltage to drop to formerly unusable levels.

As a user-selected option, the chip-enable pin, \overline{CE} , can shut down the entire IC (option A) or just the boost converter (option B), leaving the voltage detector active.

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PIN CONFIGURATION



ORDERING INFORMATION

The range for V_{OUT} is 1.5V to 6.0V, and that for V_{DET} is 1.2V to 5.0V; both come in 0.1V increments, and are user-selected.

PART CODE TC15 XX XX XX X XX XXX

\overline{CE} form: 1A*, 1B**

Output Voltage:

Ex: 15 = 1.5V; 60 = 6.0V

Detected Voltage:

Ex: 12 = 1.2V; 50 = 5.0V

Temperature: E: -40°C to +85°C

Package Type and Pin Count:

OA: 8-Pin SOIC

Taping Direction:

723: Left Taping

713: Right Taping

* A: If \overline{CE} is High (+ V_{DD}) then whole chip is disabled.

**B: If \overline{CE} is High (+ V_{DD}) then only the DC/DC converter is disabled and the detector is still operational.

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TC15 Series

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Limit	Unit
Power Supply Voltage	V_{IN}	- 0.3 to 12	V
Output Voltage of Lx pin	VLX	- 0.3 to 12	V
EXT pin	VEXT	- 0.3 to ($V_{DD} + 0.3$)	V
V_{OUT} pin	V_{OUT}	- 0.3 to ($V_{DD} + 0.3$)	V
VD_{OUT} pin	VD_{OUT}	- 0.3 to 12	V
Input Voltage of CE pin	VCE	- 0.3 to ($V_{DD} + 0.3$)	V
VD_{IN} pin	VD_{IN}	($V_{SS} - 0.3$) to ($V_{DD} + 0.3$) ($V_{SS} - 0.3$) to 12	V (ver. A) V (ver. B)
Output Current of EXT pin	IEXT	50	mA
Lx pin	ILX	250	mA
Power Dissipation	Pd	300	mW
Operating Temperature	T_A	- 40 to +85	°C
Storage Temperature	T_{stg}	- 65 to +150	°C
Soldering Condition	T_{solder}	260° 10 sec	

ELECTRICAL CHARACTERISTICS: TC151A/1B3624 (3.6V Output)

$T_A = 25^\circ\text{C}$, $V_{IN} = 4.1\text{V}$

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_{IN}	Operating Input Voltage	No Load	1.2		10	V
V_{DD}	Stepped-up Output Voltage	No Load	3.99	4.10	4.21	V
V_{OSCST}	Oscillator Start-up Voltage	No Load		0.9	1.2	V
f_{osc}	Oscillator Frequency		40	50	60	kHz
Maxdty	Maximum Oscillator Duty Cycle		65	80	90	%
V_{OL1}	Lx Output Voltage	$I_{OL} = 50\text{mA}$			0.5	V
I_{OH1}	Lx Leakage Current			0.01	10	μA
V_{LXlim}	Lx Voltage Limit	Lx pin ON		0.9		V
V_{OH}	EXT Output Pch ON Voltage	$I_{EXT} = -3\text{mA}$, $V_{IN} = 4.1\text{V}$	3.6			V
V_{OL2}	EXT Output Nch ON Voltage	$I_{EXT} = 5\text{mA}$, $V_{IN} = 4.1\text{V}$			0.5	V
V_{OUT}	Output Voltage	$I_{OUT} = 5\text{mA}$	3.51	3.60	3.69	V
V_{DIF}	Dropout Voltage	$I_{OUT} = 30\text{mA}$		0.3		V
$\Delta V_{OUT}/I_{OUT}$	Load Regulation	$-30\text{mA} \leq I_{OUT} \leq 0\text{mA}$			100	mV
$-V_{DET}$	Detector Threshold		2.34	2.4	2.46	V
V_{HYS}	Detector Threshold Hysteresis Range		60	120	240	mV
V_{OL3}	VD_{OUT} ON Voltage	$I_{OL} = 5\text{mA}$			0.5	V
I_{OH2}	VD_{OUT} Leakage Current			0.01	5	μA
I_{VDINH}	VD_{IN} "H" Input Current	$VD_{IN} = V_{IN}$			5	μA
I_{VDINL}	VD_{IN} "L" Input Current	$VD_{IN} = V_{SS}$	- 0.5		0.5	μA
V_{CEH}	CE "H" Input Voltage		$V_{DD} - 0.3$		V_{DD}	V
V_{CEL}	CE "L" Input Voltage		0		$0.2 V_{DD}$	V
I_{CEH}	CE "H" Input Current	$CE = V_{IN}$	- 0.5		0.5	μA
I_{CEL}	CE "L" Input Current	$CE = V_{SS}$	- 0.5		0.5	μA
I_{DD}	Supply Current	$V_{IN} = 3\text{V}$, $L = 100\mu\text{H}$, $C = 22\mu\text{F}$, $CE = V_{SS}$, No Load		55	120	μA
Istandby	Supply Current	$V_{IN} = 3\text{V}$, $L = 100\mu\text{H}$, $C = 22\mu\text{F}$, $CE = V_{DD}$, No Load			1.0 10.0	μA μA^2

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PRELIMINARY INFORMATION

TC15 Series

NOTES

- Standby current of version A (see "Ordering Information")
- Standby current of version B

ELECTRICAL CHARACTERISTICS: TC151A/1B5045 (5.0V Output)

$T_A = 25^\circ\text{C}$, $V_{IN} = 5.5\text{V}$

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_{IN}	Operation Input Voltage	No Load	1.2		10	V
V_{DD}	Step-up Output Voltage	No Load	5.36	5.5	5.64	V
V_{OSCST}	Oscillator Start-up Voltage	No Load		0.9	1.2	V
f_{osc}	Oscillator Frequency		40	50	60	kHz
Maxdty	Maximum Oscillator Duty Cycle		65	80	90	%
V_{OL1}	Lx Output Voltage	$I_{OL} = 50\text{mA}$			0.5	V
I_{OH1}	Lx Leakage Current			0.01	10	μA
V_{LXlim}	Lx Voltage Limit	Lx pin ON		0.9		V
V_{OH}	EXT Output Pch ON Voltage	$I_{EXT} = -3\text{mA}$, $V_{IN} = 5.5\text{V}$	5.0			V
V_{OL2}	EXT Output Nch ON Voltage	$I_{EXT} = 5\text{mA}$, $V_{IN} = 5.5\text{V}$			0.5	V
V_{OUT}	Output Voltage	$I_{OUT} = 5\text{mA}$	4.87	5.0	5.13	V
V_{DIF}	Dropout Voltage	$I_{OUT} = 30\text{mA}$		0.3		V
$\Delta V_{OUT}/I_{OUT}$	Load Regulation	$-30\text{mA} \leq I_{OUT} \leq 0\text{mA}$			100	mV
$-V_{DET}$	Detector Threshold		4.38	4.5	4.62	V
V_{HYS}	Detector Threshold Hysteresis Range		112	225	450	mV
V_{OL3}	V_{DOUT} ON Voltage	$I_{OL} = 5\text{mA}$			0.5	V
I_{OH2}	V_{DOUT} Leakage Current			0.01	5	μA
I_{VDINH}	V_{DIN} "H" Input Current	$V_{DIN} = V_{IN}$			5	μA
I_{VDINL}	V_{DIN} "L" Input Current	$V_{DIN} = V_{SS}$	-0.5		0.5	μA
V_{CEH}	\overline{CE} "H" Input Voltage		$V_{DD} - 0.3$		V_{DD}	V
V_{CEL}	\overline{CE} "L" Input Voltage		0		$0.2 V_{DD}$	V
I_{CEH}	\overline{CE} "H" Input Current	$\overline{CE} = V_{IN}$	-0.5		0.5	μA
I_{CEL}	\overline{CE} "L" Input Current	$\overline{CE} = V_{SS}$	-0.5		0.5	μA
I_{DD}	Supply Current	$V_{IN} = 4\text{V}$, $L = 100\mu\text{H}$, $C = 22\mu\text{F}$, $\overline{CE} = V_{SS}$, No Load		70	150	μA
Istandby	Supply Current	$V_{IN} = 4\text{V}$, $L = 100\mu\text{H}$, $C = 22\mu\text{F}$, $\overline{CE} = V_{DD}$, No Load			1.0 10.0	μA^1 μA^2

NOTES

- Standby current of version A (see "Ordering Information")
- Standby current of version B

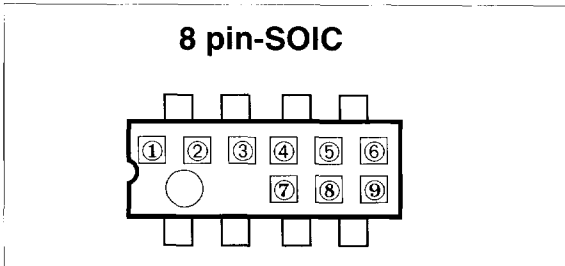
PIN DESCRIPTION

Pin No.	Symbol	Description
1	V_{SS}	Ground
2	\overline{CE}	Chip Enable. Set the pin to V_{DD} to change the device to standby state
3	V_{DOUT}	Output of voltage detector (NMOS open drain output)
4	V_{DIN}	Input to voltage detector

Pin No.	Symbol	Description
5	V_{OUT}	Output of voltage regulator
6	V_{DD}	Input to linear regulator from boost converter
7	EXT	Output drive for external PWM switch transistor
8	Lx	Input to internal switch (from L)

TC15 Series

MARKING



a & b represent 15: Fixed

c represents first digit of voltage

Mark c	Volt
1	1.d (V)
2	2.d (V)
3	3.d (V)
4	4.d (V)
5	5.d (V)
6	6.d (V)

d represents first decimal place of voltage

Mark d	Volt	Mark d	Volt
0	c.0 (V)	5	c.5 (V)
1	c.1 (V)	6	c.6 (V)
2	c.2 (V)	7	c.7 (V)
3	c.3 (V)	8	c.8 (V)
4	c.4 (V)	9	c.9 (V)

e represents detected voltage

Mark e	V _{DET}	Mark e	V _{DET}	Mark e	V _{DET}
0	1.2	C	2.9	R	5.0
1	1.5	D	3.0	S	1.3
2	1.8	E	3.1	T	3.7
3	1.9	F	3.3		
4	2.0	G	3.5		
5	2.1	H	3.6		
6	2.2	J	4.0		
7	2.4	K	4.1		
8	2.5	L	4.3		
9	2.6	M	4.5		
A	2.7	N	4.7		
B	2.8	O	4.8		

f represents CE version

Mark f	Version
A	A
B	B

g, h and i, represents assembly lot number

TEST CIRCUITS (Keyed to following graphs)

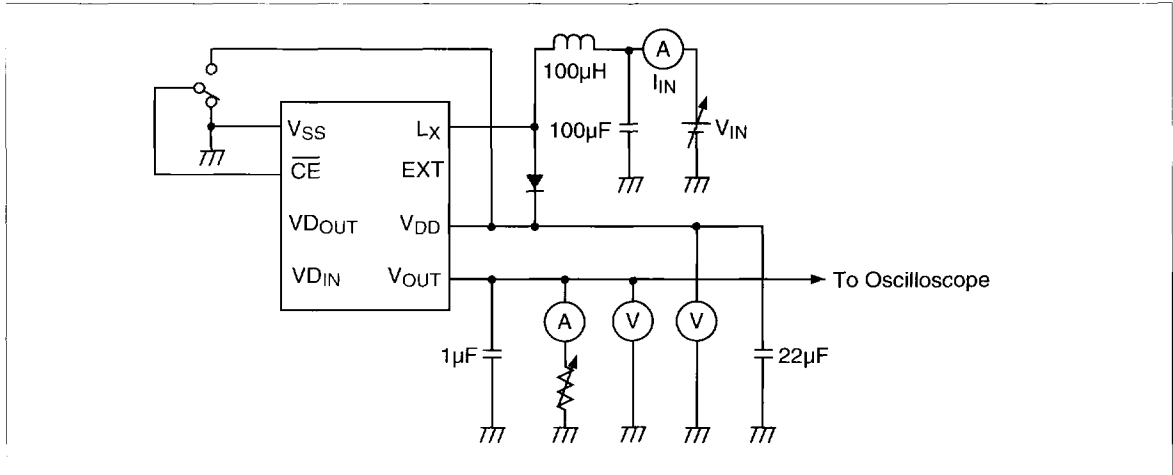


Figure 1 Test Circuit 1

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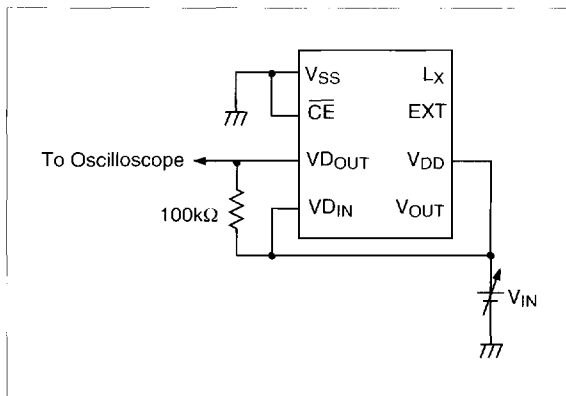


Figure 2 Test Circuit 2

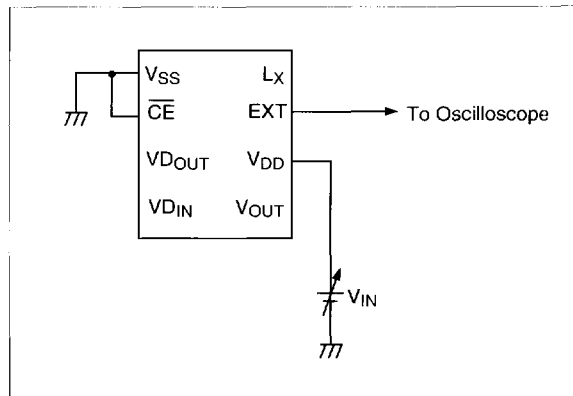


Figure 3 Test Circuit 3

Test Circuit 1 Applies to graphical characteristics 1) - 4), 7), 8) and 11) - 14)
[Change the 100µF capacitance to 1µF for characteristics 13) and 14)
STANDBY state: $\overline{CE} = V_{DD}$]

Test Circuit 2 Applies to graphical characteristics 9) and 10)

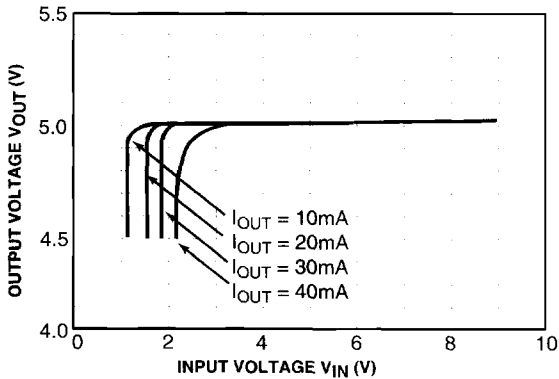
Test Circuit 3 Applies to graphical characteristics 5) and 6)
Definition of efficiency is as follows: $(V_{OUT} \times I_{OUT}) \div (V_{IN} \times I_{IN})$

TC15 Series

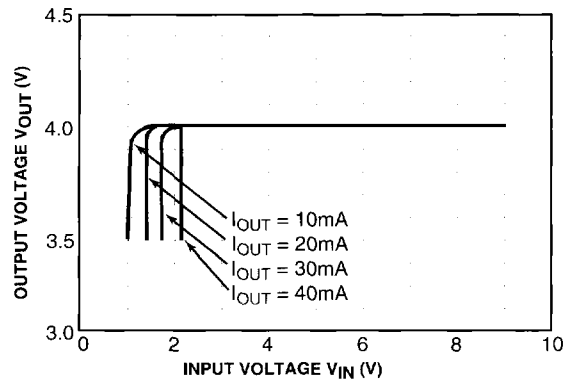
TYPICAL CHARACTERISTICS

1) Output Voltage vs. Input Voltage

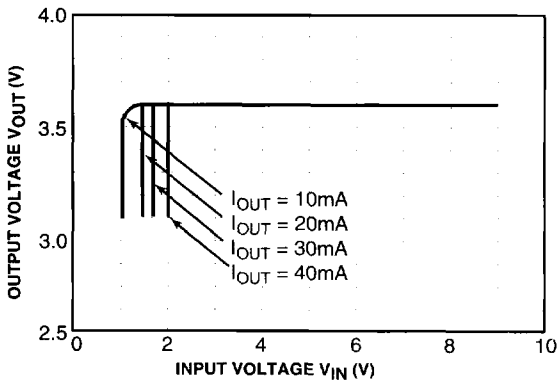
TC151A5045



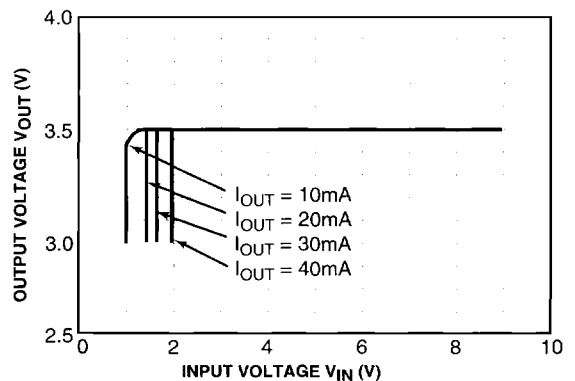
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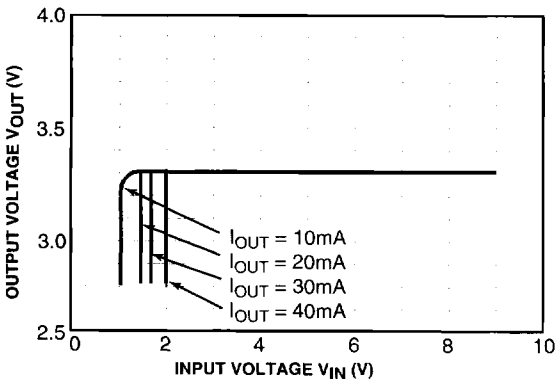
TC151A3624



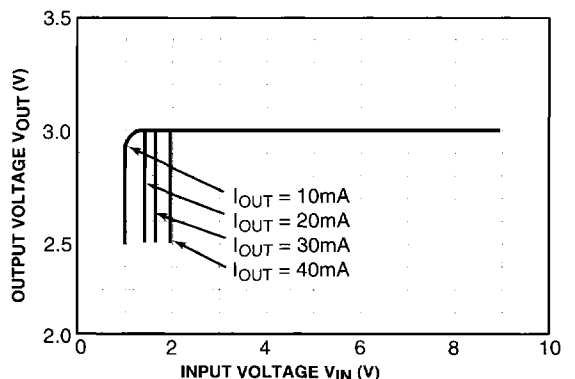
TC151A3531



TC151A3329



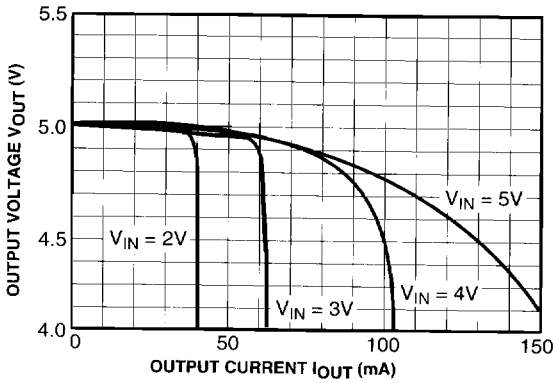
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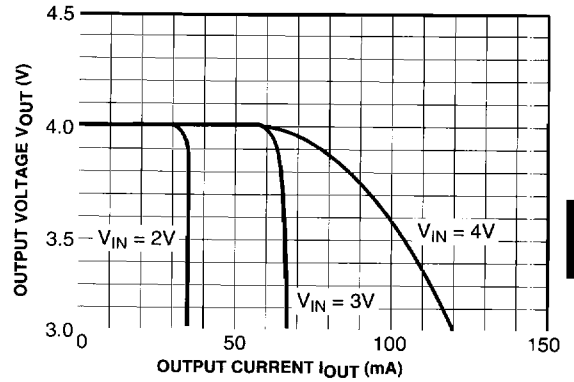
TYPICAL CHARACTERISTICS

2) Output Voltage vs. Output Current ($T_A = 25^\circ\text{C}$)

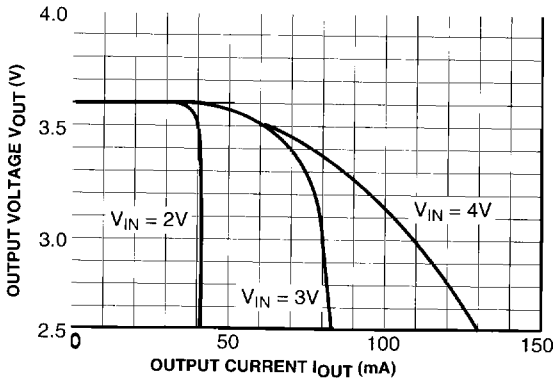
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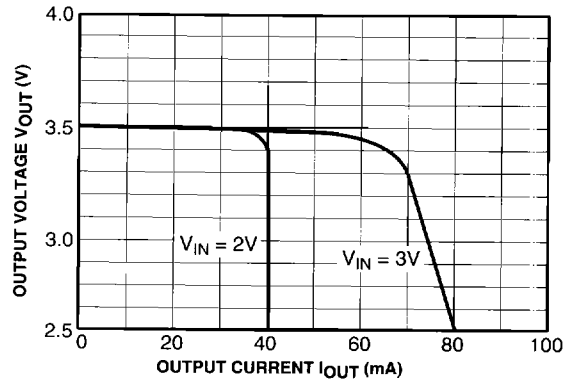
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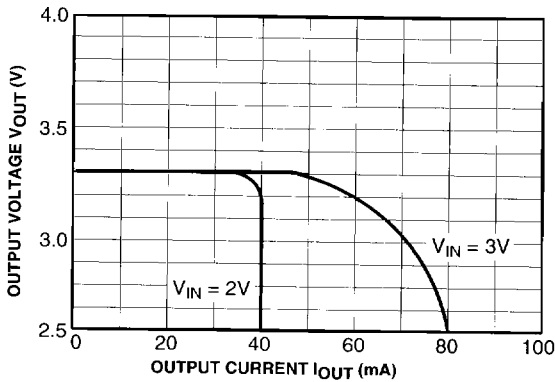
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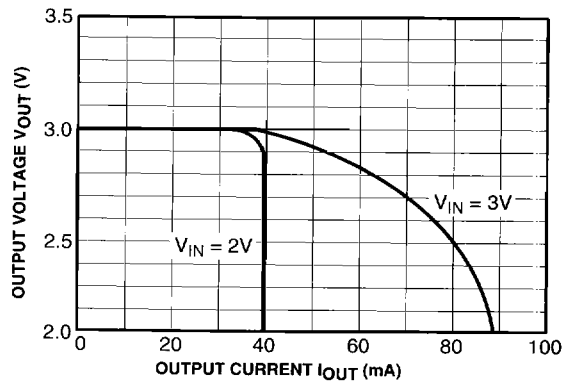
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TC151A3329



TC151A3027



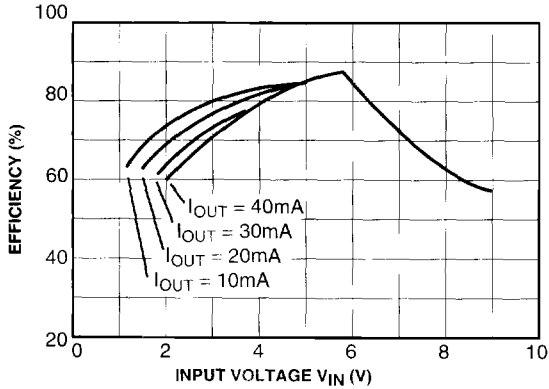
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TC15 Series

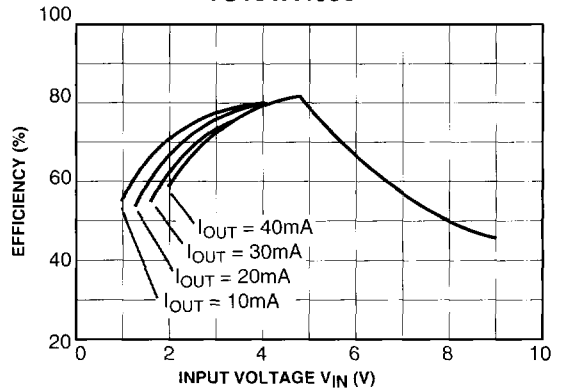
TYPICAL CHARACTERISTICS

3) Efficiency vs. Input Voltage ($T_A = 25^\circ\text{C}$)

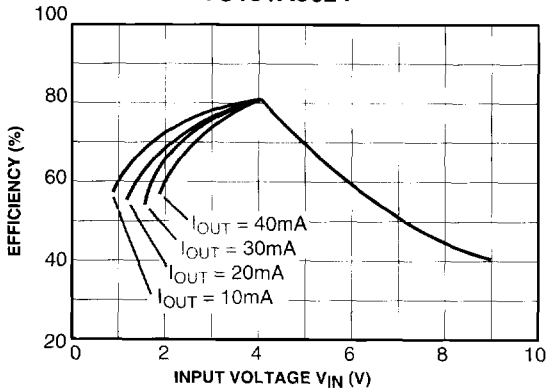
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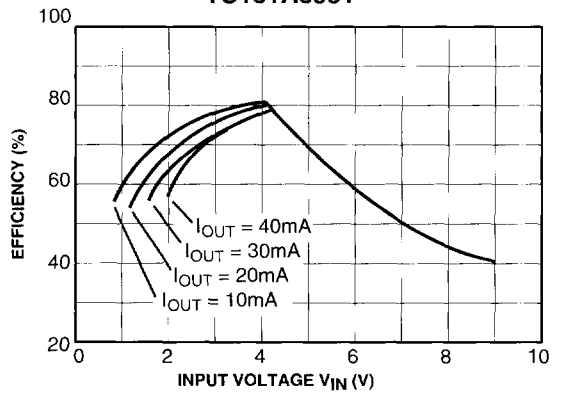
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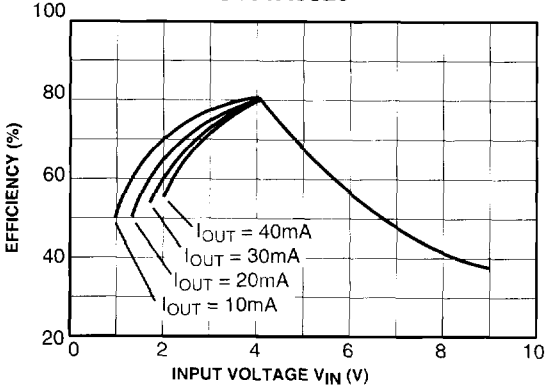
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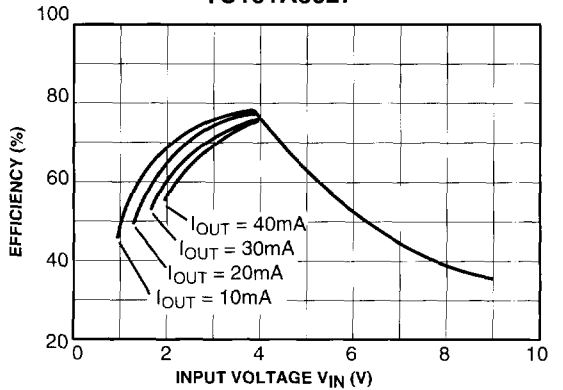
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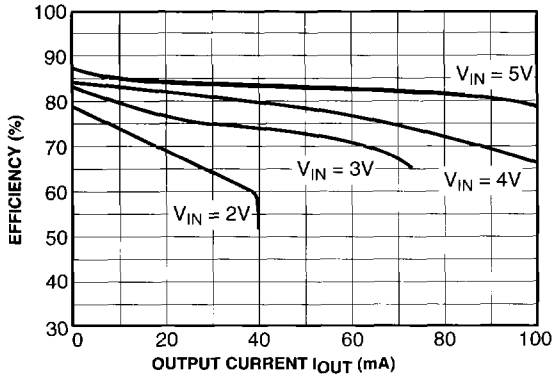
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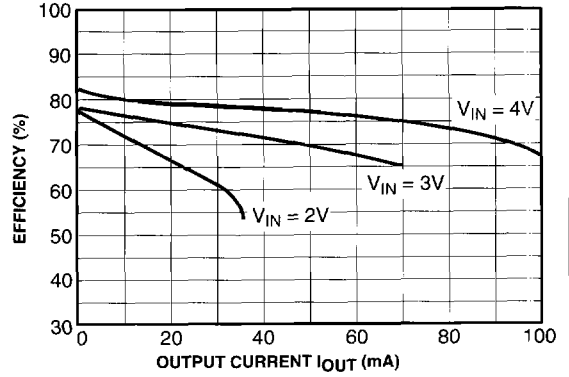
TYPICAL CHARACTERISTICS

4) Efficiency vs. Output Current ($T_A = 25^\circ\text{C}$)

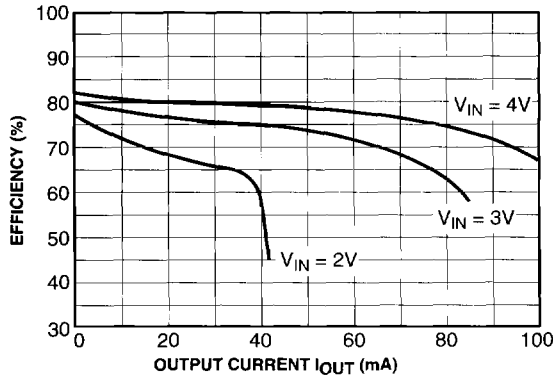
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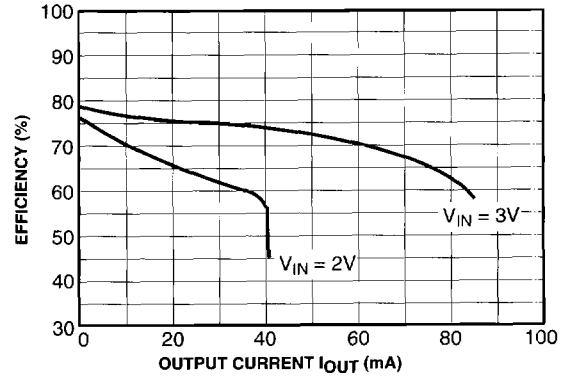
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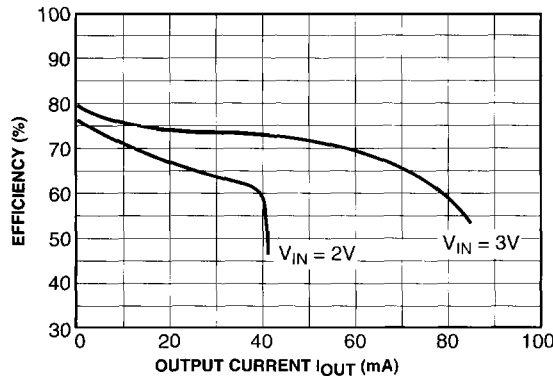
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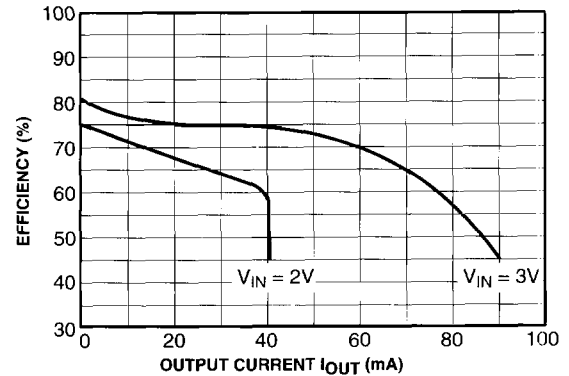
TC151A3531



TC151A3329



TC151A3027

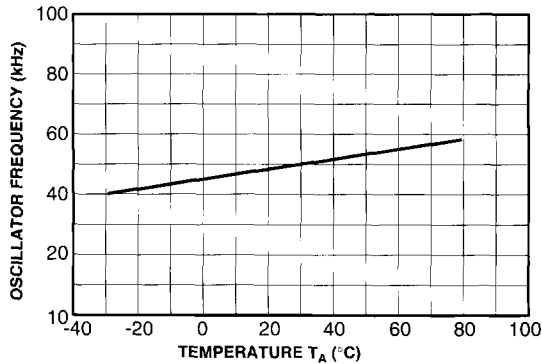


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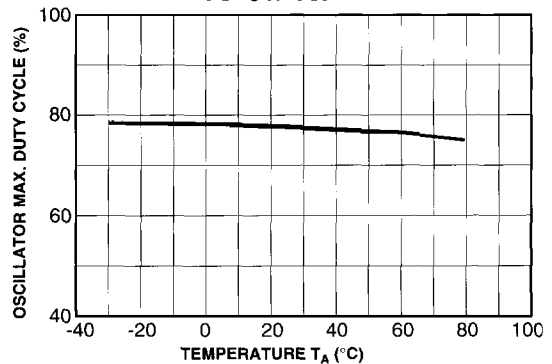
TC15 Series

TYPICAL CHARACTERISTICS

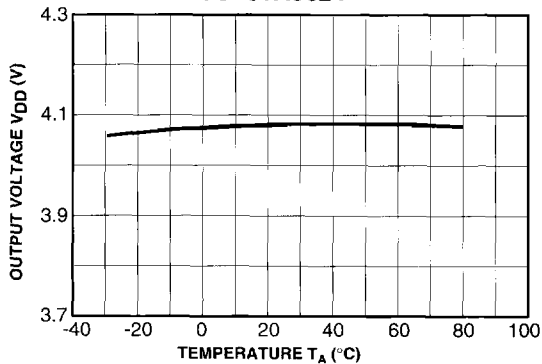
**5) Oscillator Frequency vs. Temperature
TC151A3624**



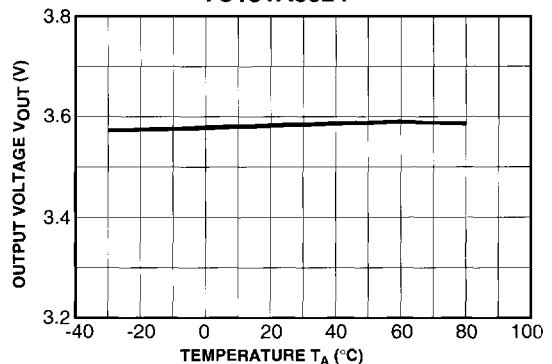
**6) Oscillator Maximum Duty Cycle vs. Temperature
TC151A3624**



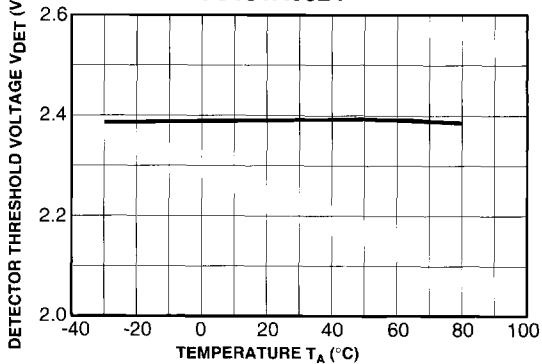
**7) Output Voltage V_{DD} vs. Temperature
TC151A3624**



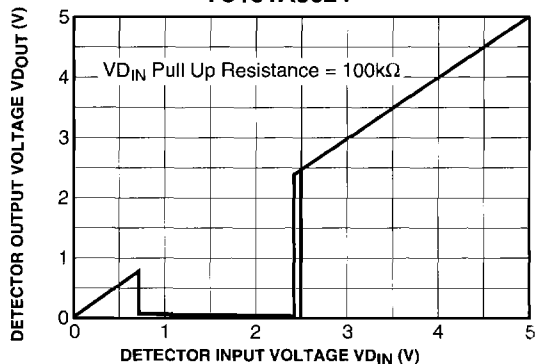
**8) Output Voltage V_{OUT} vs. Temperature
TC151A3624**



**9) Detector Threshold vs. Temperature
TC151A3624**

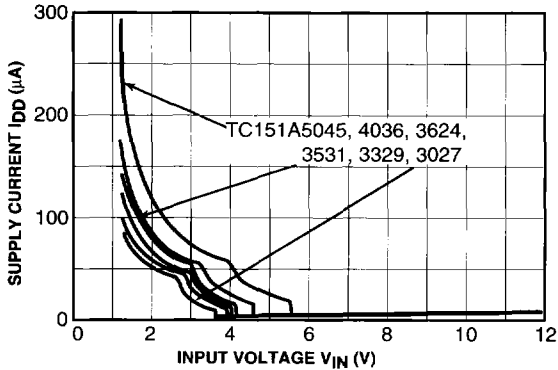


**10) Detector Output Voltage vs. Detector Input Voltage
TC151A3624**

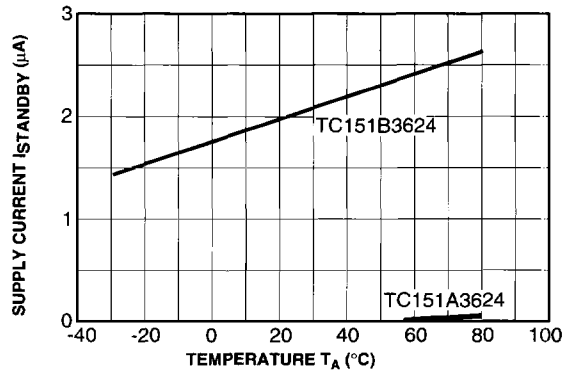


TYPICAL CHARACTERISTICS

**11) Supply Current (No Load) vs. Input Voltage
TC151AXXX**



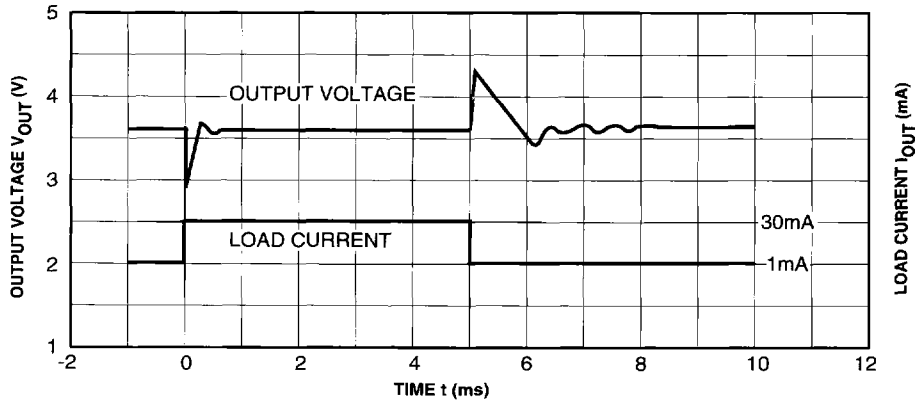
**12) Supply Current (No Load) vs. Temperature
TC151A3624/1B3624**



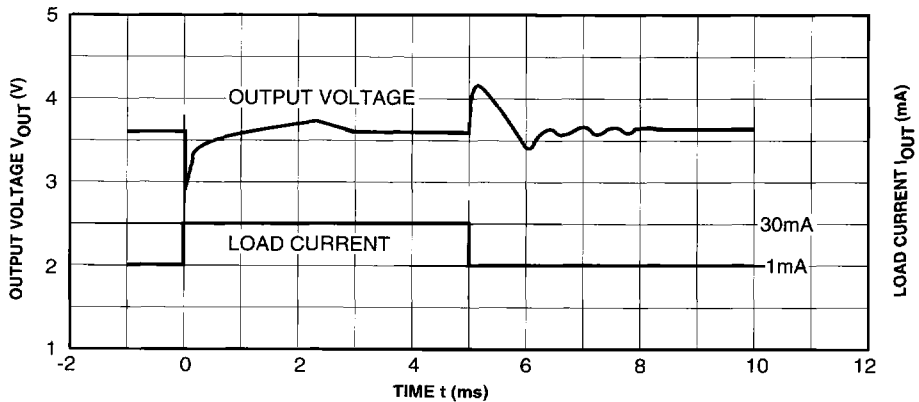
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13) Load Transient Response TC151A3624

1) $V_{IN} = 3V$



2) $V_{IN} = 5V$

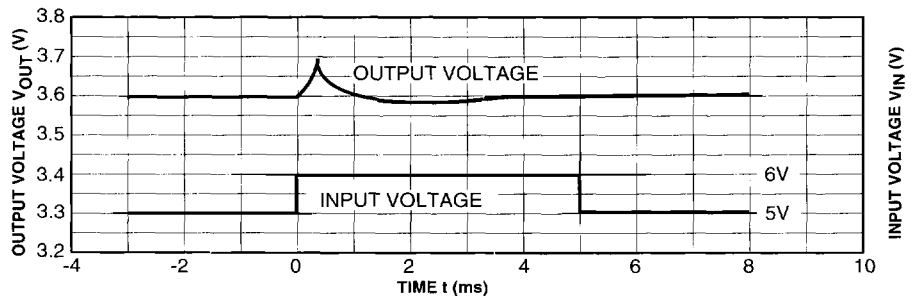
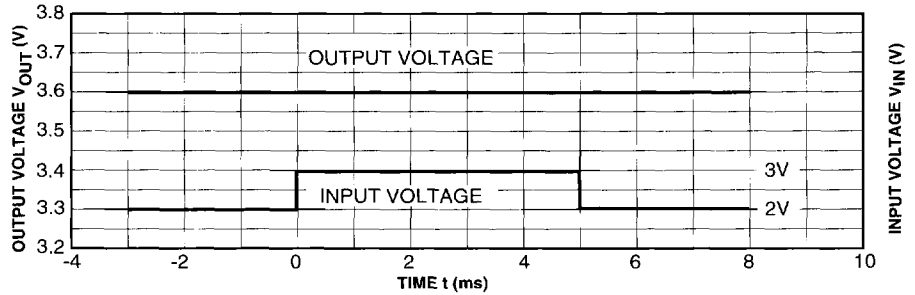


TC15 Series

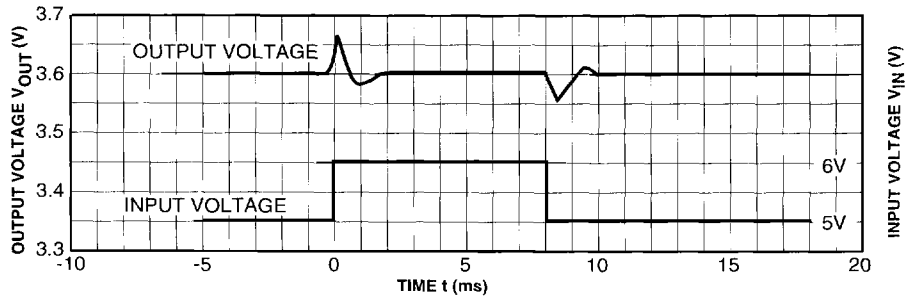
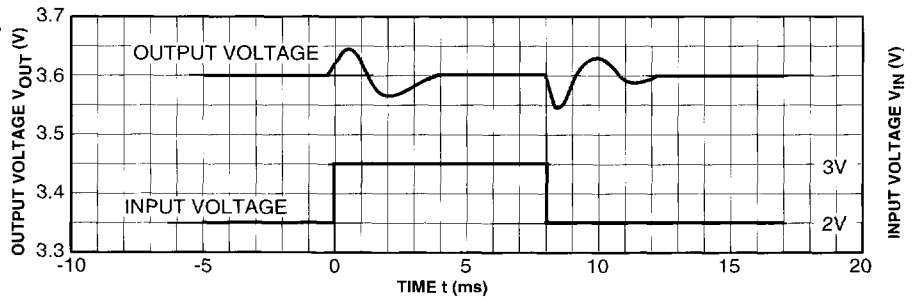
TYPICAL CHARACTERISTICS

14) Line Transient Response

1) $I_{OUT} = -1mA$



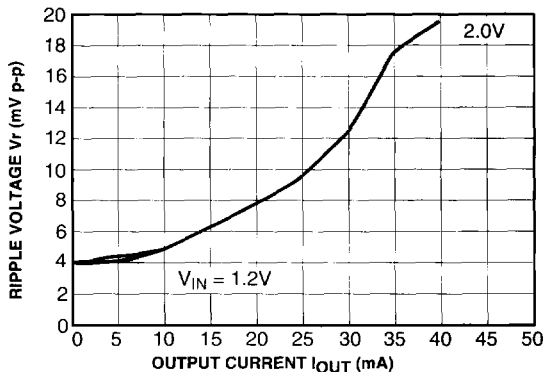
2) $I_{OUT} = -30mA$



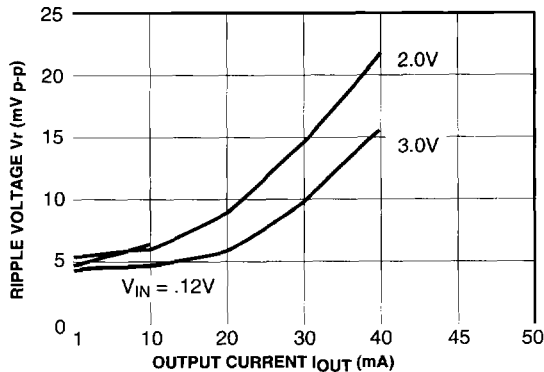
TYPICAL CHARACTERISTICS

15) Output Ripple Voltage vs. Output Current ($T_A = 25^\circ\text{C}$)

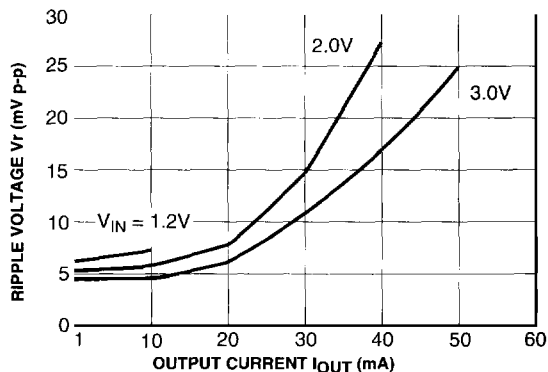
TC151B3027



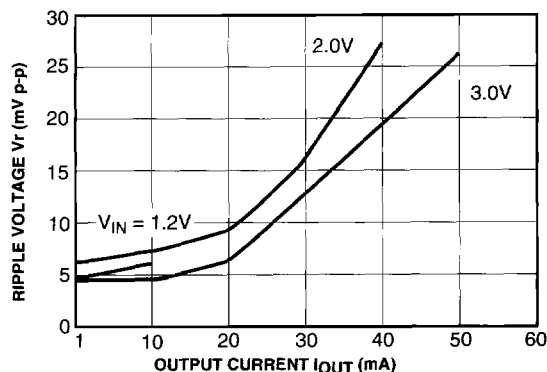
TC151B3329



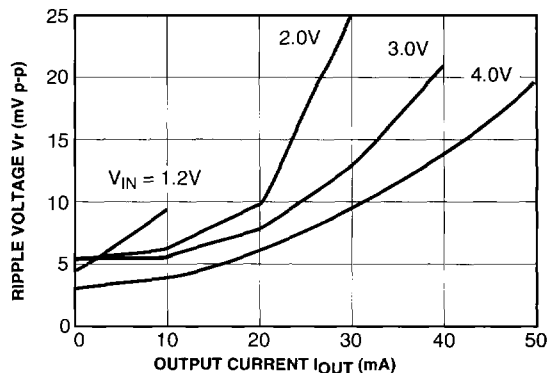
TC151B3531



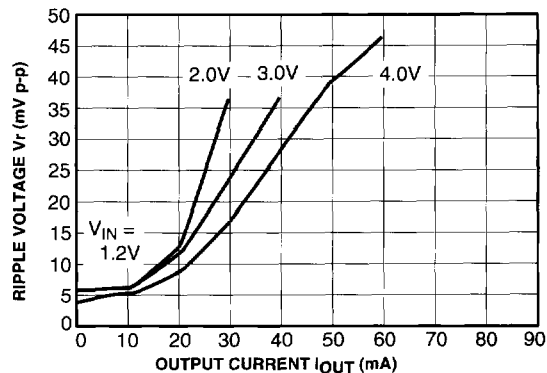
TC151B3624



TC151B4036



TC151B5045



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