ULTRA-SMALL, LOW-INPUT-VOLTAGE, LOW r_{ON} LOAD SWITCH WITH HYSTERESIS CONTROL INPUT

Check for Samples: TPS22934

FEATURES

- **Integrated Single-Channel Load Switch**
- **Ultra Small CSP-4 package 0.9 mm x 0.9 mm, 0.5-mm Pitch, 0.5-mm Thick**
- **Input Voltage: 1.5 V to 3.6 V**
- **Ultra-Low ON Resistance**
  - $r_{DS(ON)}$ = 63 mΩ at V_{IN} = 3.6 V
  - $r_{DS(ON)}$ = 69 mΩ at V_{IN} = 2.5 V
  - $r_{DS(ON)}$ = 78 mΩ at V_{IN} = 1.8 V
  - $r_{DS(ON)}$ = 87 mΩ at V_{IN} = 1.5 V
- **1-A Maximum Continuous Switch Current**
- **Integrated Hysteresis Enable Input (ON Pin) Allows Easy Power Rail Sequencing**
- **Controlled Slew Rate Option: 26 µs at 3.6 V**
- **Quick Output Discharge Transistor**
- **ESD Performance Tested Per JESD 22**
  - **3000-V Human-Body Model (A114-B, Class II)**
  - **1000-V Charged-Device Model (C101)**

APPLICATIONS

- **Battery Powered Equipment**
- **Portable Industrial Equipment**
- **Portable Medical Equipment**
- **Portable Media Players**
- **Point Of Sales Terminal**
- **GPS Devices**
- **Digital Cameras**
- **Portable Instrumentation**
- **Smartphones**

DESCRIPTION

The TPS22934 is a small, ultra low ON-resistance (r_{ON}) load switch with controlled turn on. The devices contain a P-channel MOSFETs that can operate over an input voltage range of 1.5 V to 3.6 V.

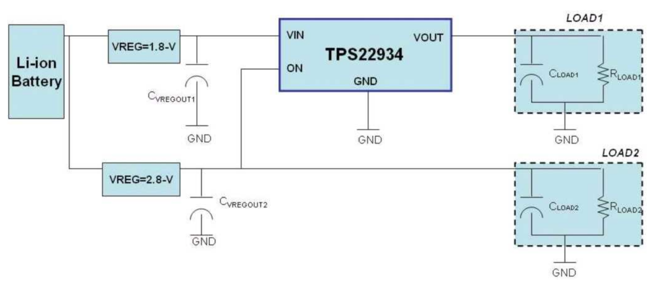
The switch is controlled by an on/off input (ON), which has built in hysteresis ($V_{TH+(typ)}$ = 2.35 V) allowing an easy use of TPS22934 in power-rail sequencing applications.

In TPS22934 a 35-Ω on-chip load resistor is added for output quick discharge when switch is turned off.

In TPS22934, the rise time of the device is internally controlled in order to avoid inrush current. TPS22934 feature a typical rise time of 26 µs with a 3.6-V input.

The TPS22934 is available in an ultra-small space-saving 4-pin CSP package and is characterized for operation over the free-air temperature range of –40ºC to 85ºC.

TYPICAL APPLICATION
1.8-V Power Rail Sequencing



FEATURE LIST

	r_{ON} (TYP) AT 3.6 V	SLEW RATE (TYP) AT 3.6 V	QUICK OUTPUT DISCHARGE	MAXIMUM OUTPUT CURRENT	ENABLE
TPS22934	63 mΩ	26 µs	Yes	1 A	Hysteresis Input $V_{TH+(typ)}$ = 2.35 V

ORDERING INFORMATION(1)

T_A	PACKAGE(2)		ORDERABLE PART NUMBER	TOP-SIDE MARKING(3)
–40°C to 85°C	DSBGA – YZP (0.5-mm pitch)	Tape and reel	TPS22934YZVR	_ _ _ _ 6 2
		Tape and reel	TPS22934YZVT	

(1) 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 www.ti.com.
(2) Package drawings, thermal data, and symbolization are available at www.ti.com/packaging.
(3) The actual top-side marking has four preceding characters to denote year, month, sequence code, and the wafer fab/assembly site. Pin 1 identifier indicates solder-bump composition (1 = SnPb, ● = Pb-free).

```
+----------+        Y             = YEAR
|          |        M             = MONTH
| YMSN     |        S             = LOT SEQUENCE
|   62     |        4TH CHAR      = WAFER FAB/ASSEMBLY SITE CODE
| ●        |        LINE 2        = DEVICE NAME CODE
+----------+        ●             = PIN ONE (FILLED CIRCLE)
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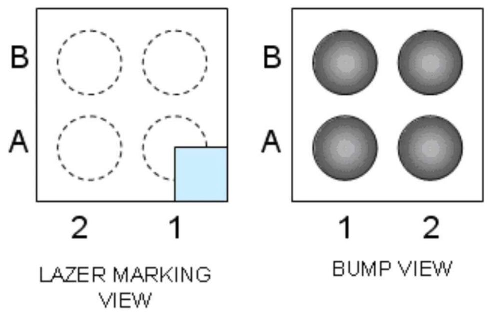
YZV PACKAGE



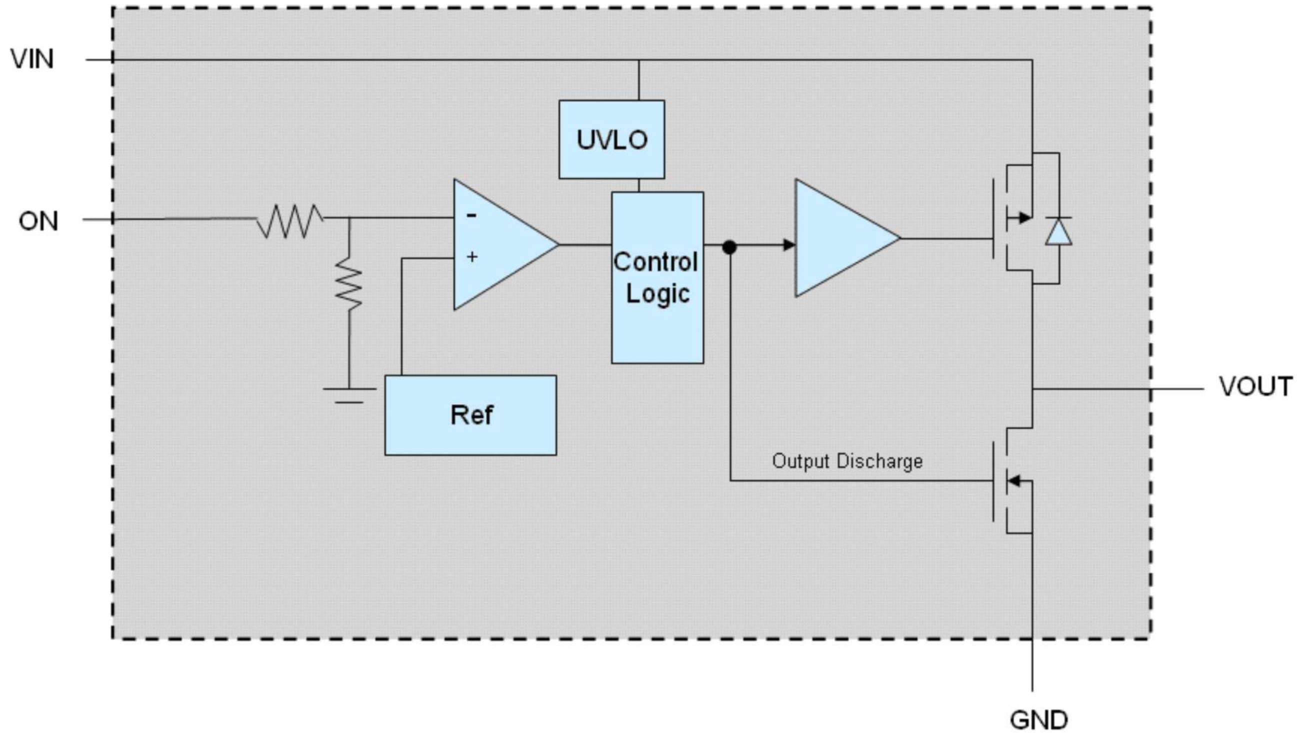
TERMINALS ASSIGNMENTS (YZP PACKAGE)

B	ON	GND
A	VIN	VOUT
	2	**1**

TERMINAL FUNCTIONS

NO.	NAME	DESCRIPTION
B1	GND	Ground
B2	ON	Switch control input, active high. Do not leave floating
A1	VOUT	Switch output
A2	VIN	Switch input, bypass this input with a ceramic capacitor to ground

BLOCK DIAGRAM



FUNCTION TABLE

ON (Control Signal)	VIN to VOUT	VOUT to GND
VON < V_{TH-}	OFF	ON
VON > V_{TH+}	ON	OFF

ABSOLUTE MAXIMUM RATINGS[(1)]

			MIN	MAX	UNIT
V_{IN}	Input voltage range		–0.3	4	V
V_{OUT}	Output voltage range			V_{IN} + 0.3	V
V_{ON}	Control input voltage range		–0.3	4	V
I_{MAX}	Maximum continuous switch current, T_A = -40°C to 85°C			1	A
I_{PLS}	Maximum pulsed switch current, 100-µs pulse, 2% duty cycle, T_A = -40°C to 85°C			1.4	A
T_A	Operating free-air temperature range		–40	85	°C
T_{stg}	Storage temperature range		–65	150	°C
ESD	Electrostatic discharge protection	Human-Body Model (HBM)		3000	V
		Charged-Device Model (CDM)		1000	

(1) 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 RATINGS

BOARD	PACKAGE	$R_{\theta JC}$	$R_{\theta JA}$	DERATING FACTOR ABOVE T_A = 25°C	T_A < 25°C	T_A = 70°C	T_A = 85°C
High-K[(1)]	YZV	28.18°C/W	120.62°C/W	-8.2904 mW/°C	829.04 mW	455.97 mW	331.61 mW

(1) The JEDEC high-K (2s2p) board used to derive this data was a 3- × 3-inch, multilayer board with 1-ounce internal power and ground planes and 2-ounce copper traces on top and bottom of the board.

RECOMMENDED OPERATING CONDITIONS

		MIN	MAX	UNIT
V_{IN}	Input voltage	1.5	3.6	V
V_{ON}	Control input voltage	0	3.6	
V_{OUT}	Output voltage		V_{IN}	V
C_{IN}	Input capacitance	1[(1)]		µF

(1) See the *Input Capacitor* section in *Application Information*.

ELECTRICAL CHARACTERISTICS

V_{IN} = 1.5 V to 3.6 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS		T_A	MIN	TYP[(1)]	MAX	UNIT
I_{IN}	Quiescent current	I_{OUT} = 0, V_{IN} = V_{ON} = 3.6 V		Full		3.5	20	µA
$I_{IN(OFF)}$	OFF-state supply current	V_{ON} = GND, V_{OUT} = 0		Full		2.5	5	µA
r_{ON}	ON-state resistance	I_{OUT} = -200 mA	V_{IN} = 3.6 V	25°C		63	77	mΩ
				Full			80	
			V_{IN} = 2.5 V	25°C		69	85	
				Full			89	
			V_{IN} = 1.8 V	25°C		78	96	
				Full			100	
			V_{IN} = 1.5 V	25°C		87	107	
				Full			115	
r_{PD}	Output pulldown resistance	V_{IN} = 3.3 V, V_{ON} < V_{TH-}, I_{OUT} = 30 mA		25°C		35	65	Ω
I_{ON}	ON input bias current	V_{ON} = 1.5 V to 3.6 V or GND		Full		0.7	1.5	µA
UVLO	Undervoltage lockout	V_{IN} increasing	V_{ON} = 3.6 V, I_{OUT} = -100 mA	Full	0.8	1.05	1.4	V
		V_{IN} decreasing		Full	0.7	0.95	1.3	
V_{TH+}	Positive going ON voltage threshold	V_{IN} = 1.5 V to 3.6 V		Full	2.1	2.35	2.7	V
V_{TH-}	Negative going ON voltage threshold	V_{IN} = 1.5 V to 3.6 V		Full	1.3	1.45	1.6	V
ΔV_{TH}	Hysteresis ($V_{TH+} - V_{TH-}$)	V_{IN} = 1.5 V to 3.6 V		Full	0.7	0.9	1.1	V

(1) Typical values are at V_{IN} = 3.3 V and T_A = 25°C.

SWITCHING CHARACTERISTICS

V_{IN} = 3.6 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
t_{ON}	Turn-ON time	R_L = 500 Ω, C_L = 0.1 µF		33		µs
t_{OFF}	Turn-OFF time	R_L = 500 Ω, C_L = 0.1 µF		17		µs
t_r	V_{OUT} rise time	R_L = 500 Ω, C_L = 0.1 µF		26		µs
t_f	V_{OUT} fall time	R_L = 500 Ω, C_L = 0.1 µF		7.5		µs

SWITCHING CHARACTERISTICS

V_{IN} = 2.5 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
t_{ON}	Turn-ON time	R_L = 500 Ω, C_L = 0.1 µF		42		µs
t_{OFF}	Turn-OFF time	R_L = 500 Ω, C_L = 0.1 µF		17		µs
t_r	V_{OUT} rise time	R_L = 500 Ω, C_L = 0.1 µF		31		µs
t_f	V_{OUT} fall time	R_L = 500 Ω, C_L = 0.1 µF		8		µs

SWITCHING CHARACTERISTICS

V_{IN} = 1.8 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
t_{ON}	Turn-ON time	R_L = 500 Ω, C_L = 0.1 µF		54		µs
t_{OFF}	Turn-OFF time	R_L = 500 Ω, C_L = 0.1 µF		15		µs
t_r	V_{OUT} rise time	R_L = 500 Ω, C_L = 0.1 µF		37		µs
t_f	V_{OUT} fall time	R_L = 500 Ω, C_L = 0.1 µF		10		µs

SWITCHING CHARACTERISTICS

V_{IN} = 1.5 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
t_{ON}	Turn-ON time	R_L = 500 Ω, C_L = 0.1 µF		64		µs
t_{OFF}	Turn-OFF time	R_L = 500 Ω, C_L = 0.1 µF		14		µs
t_r	V_{OUT} rise time	R_L = 500 Ω, C_L = 0.1 µF		42		µs
t_f	V_{OUT} fall time	R_L = 500 Ω, C_L = 0.1 µF		12		µs

PARAMETER MEASURMENT INFORMATION

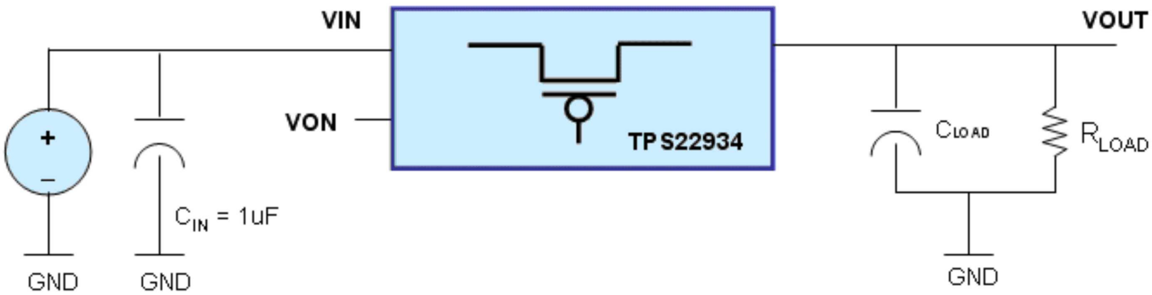
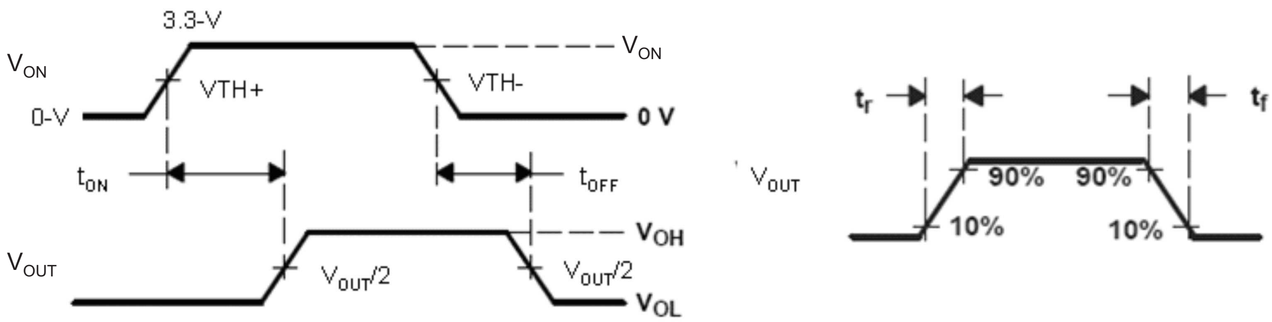


Figure 1 : Test Circuit

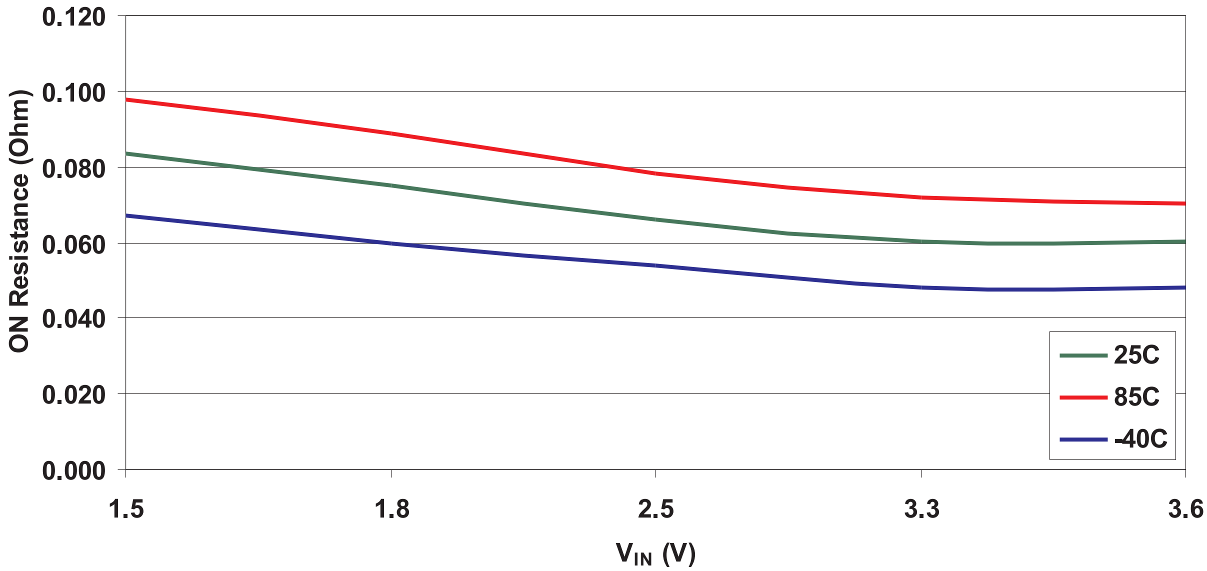


t_{ON} / t_{OFF} WAVEFORMS

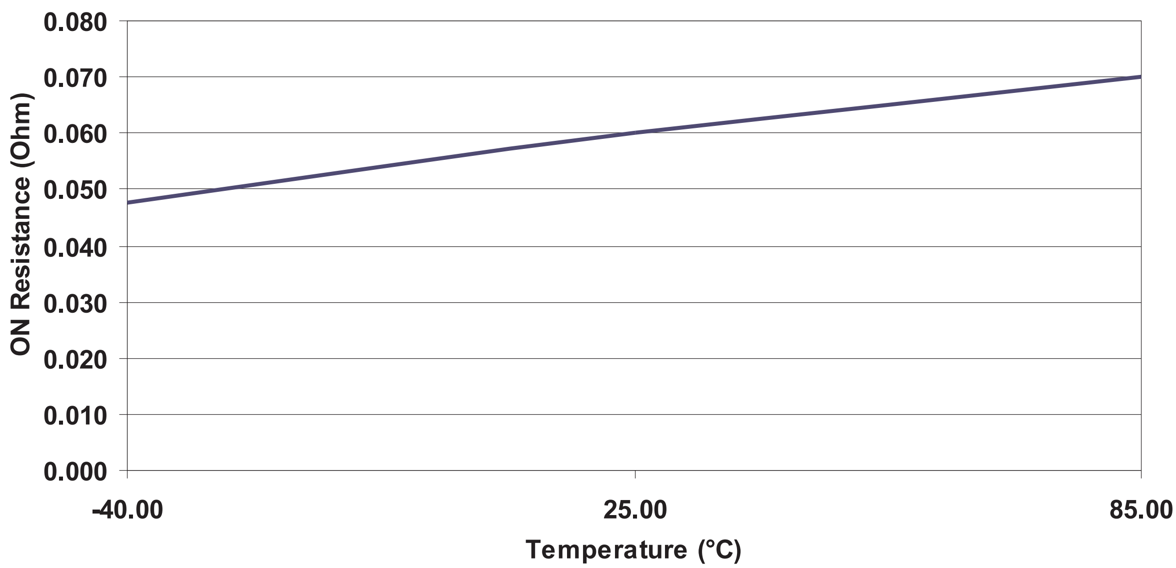
Figure 1. Test Circuit and t_{ON}/t_{OFF} Waveforms

TYPICAL CHARACTERISTICS

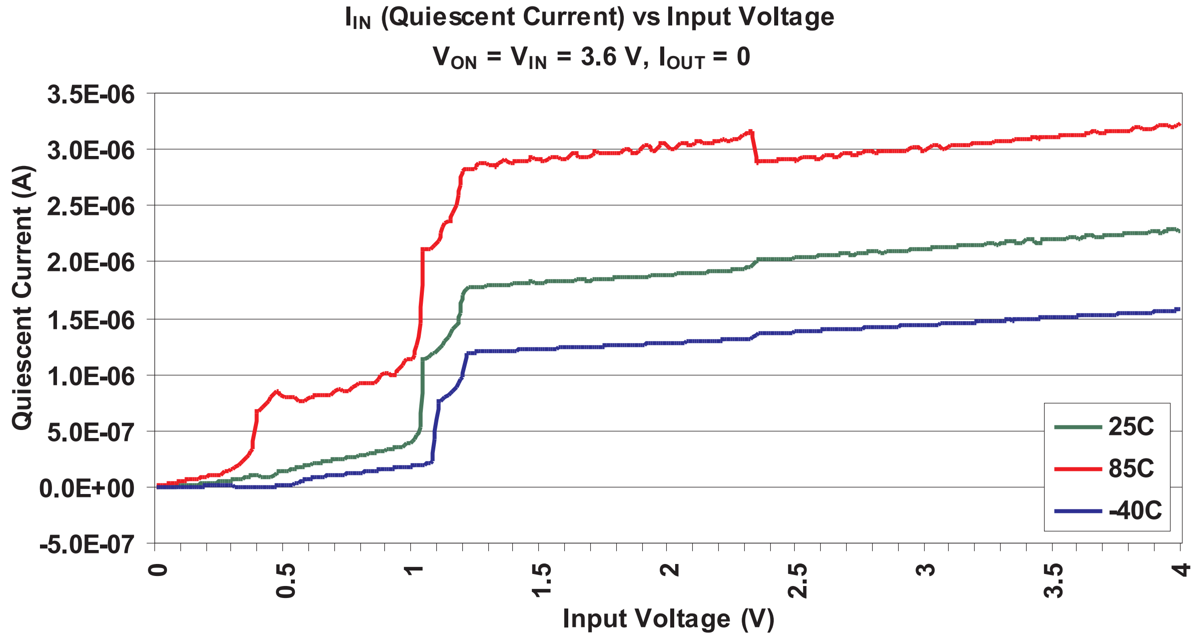
ON Resistance vs Input Voltage
I_{OUT} = -200 mA

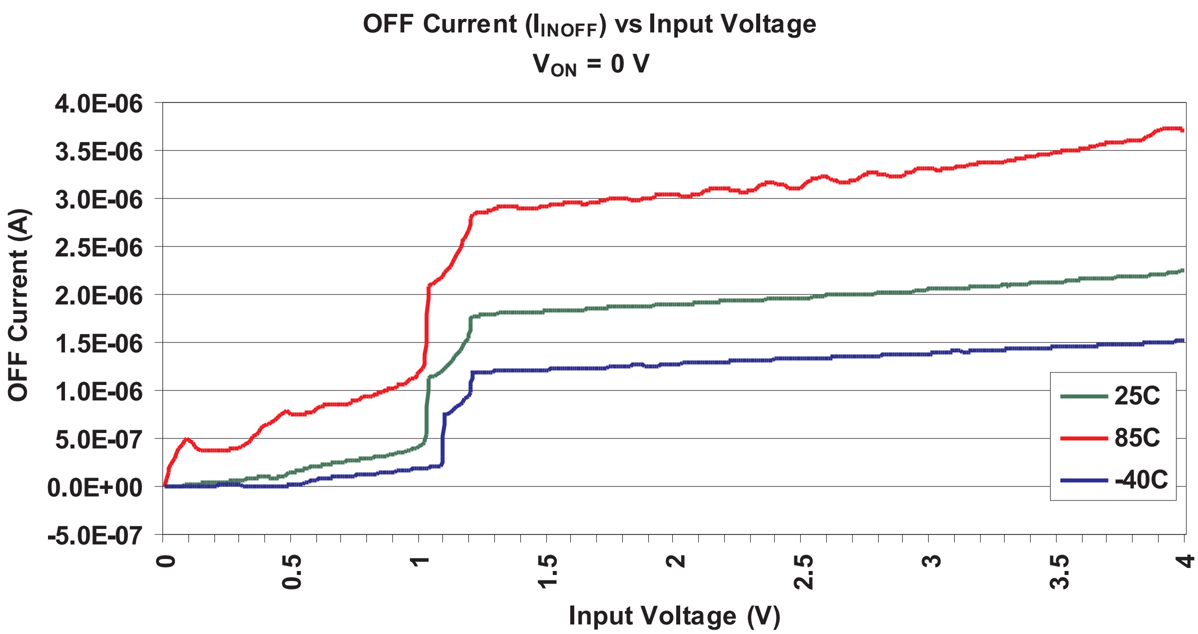


ON Resistance vs Temperature
V_{IN} = 3.6 V, I_{OUT} = -200 mA



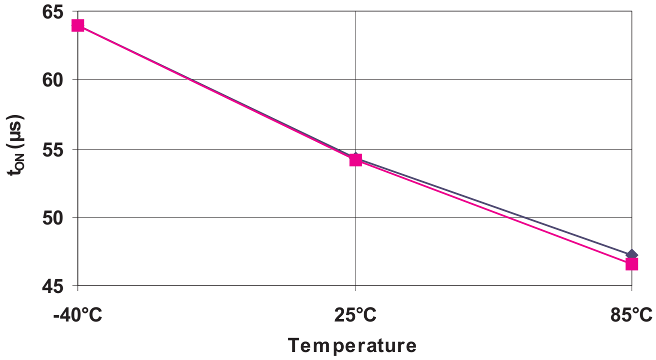
TYPICAL CHARACTERISTICS (continued)



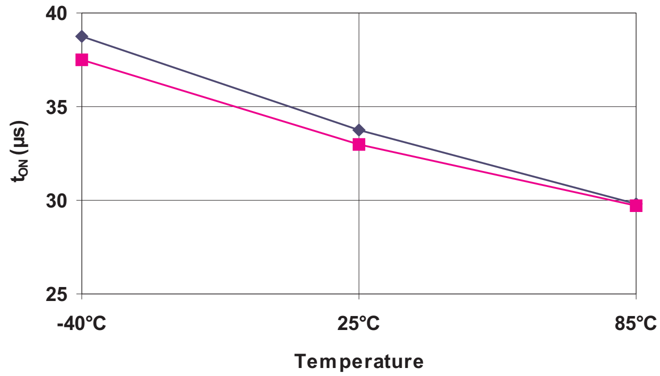


TYPICAL CHARACTERISTICS (continued)

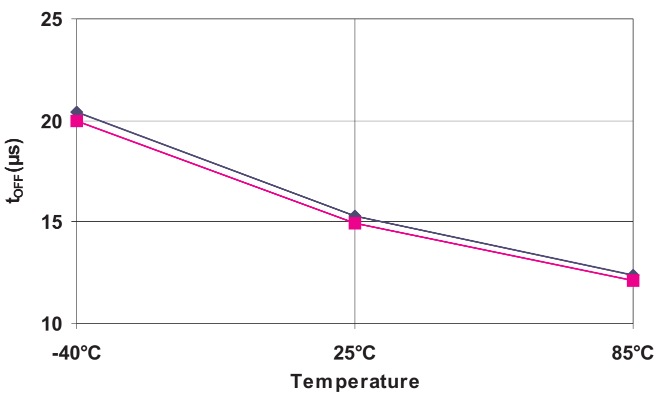
t_{ON} vs Temperature (V_{IN} = 1.8 V)
C_L = 0.1 µF, R_L = 500 Ω



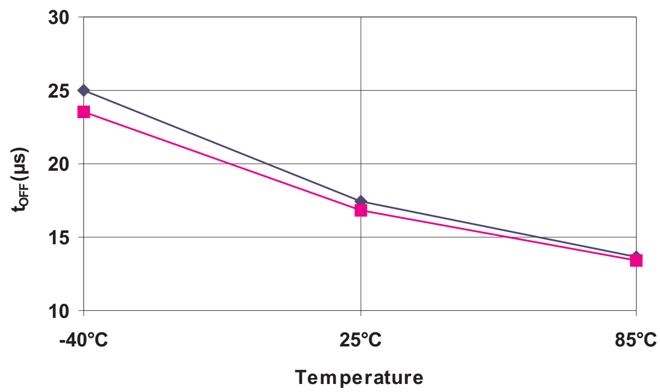
t_{ON} vs Temperature (V_{IN} = 3.6 V)
C_L = 0.1 µF, R_L = 500 Ω



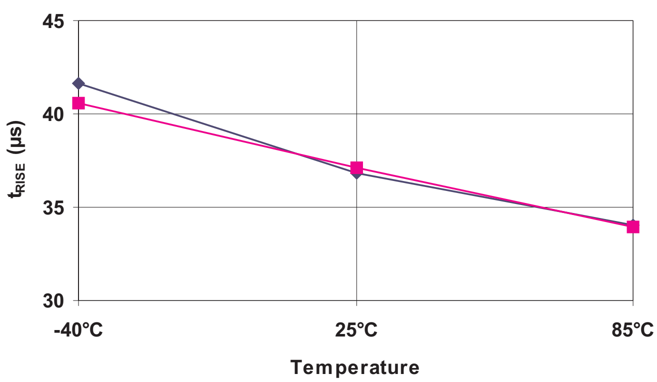
t_{OFF} vs Temperature (V_{IN} = 1 .8 V)
C_L = 0.1 µF, R_L = 500 Ω



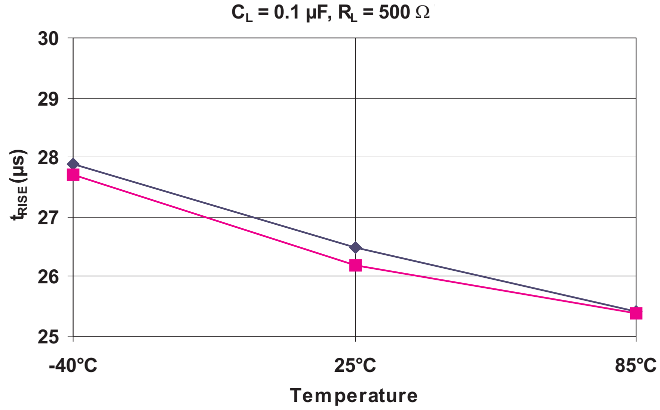
t_{OFF} vs Temperature (V_{IN} = 3.6 V)
C_L = 0.1 µF, R_L = 500 Ω



t_{RISE} vs Temperature (V_{IN} = 1.8 V)
C_L = 0.1 µF, R_L = 500 Ω

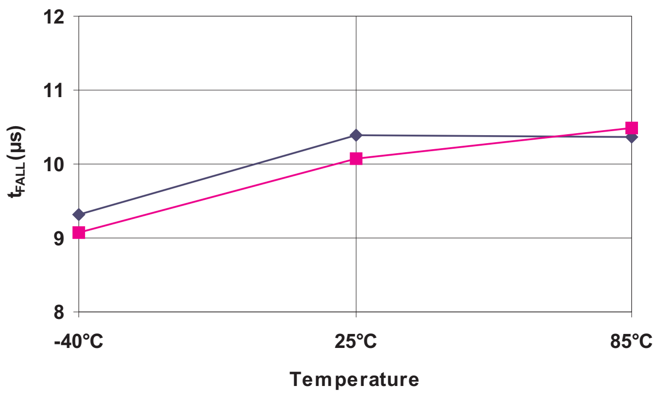


t_{RISE} vs Temperature (V_{IN} = 3.6 V)
C_L = 0.1 µF, R_L = 500 Ω

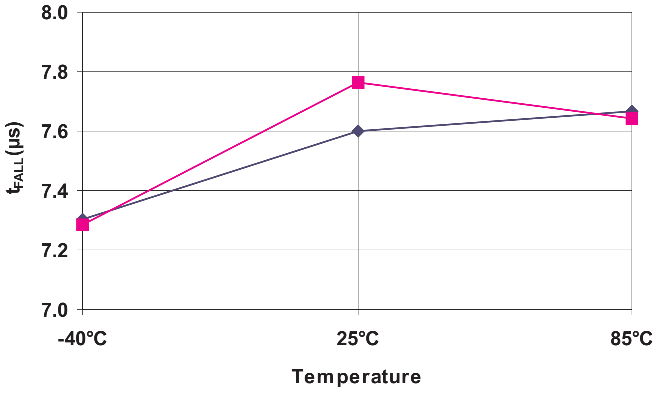


TYPICAL CHARACTERISTICS (continued)

t_{FALL} vs Temperature (V_{IN} = 1.8 V)
C_L = 0.1 µF, R_L = 500 Ω



t_{FALL} vs Temperature (V_{IN} = 3.6 V)
C_L = 0.1 µF, R_L = 500 Ω



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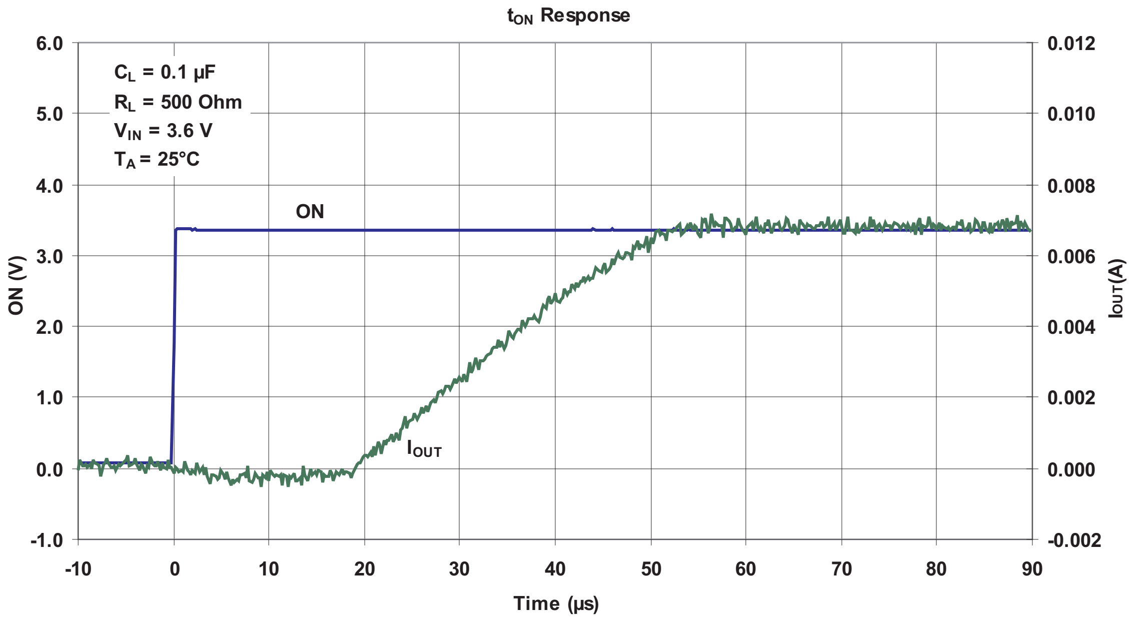

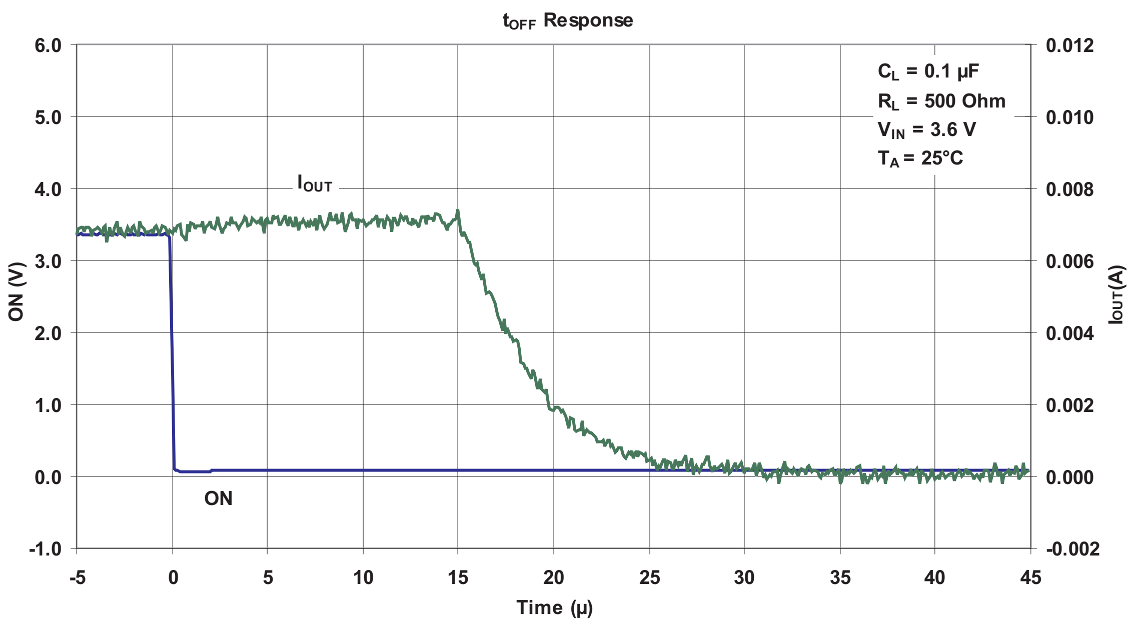

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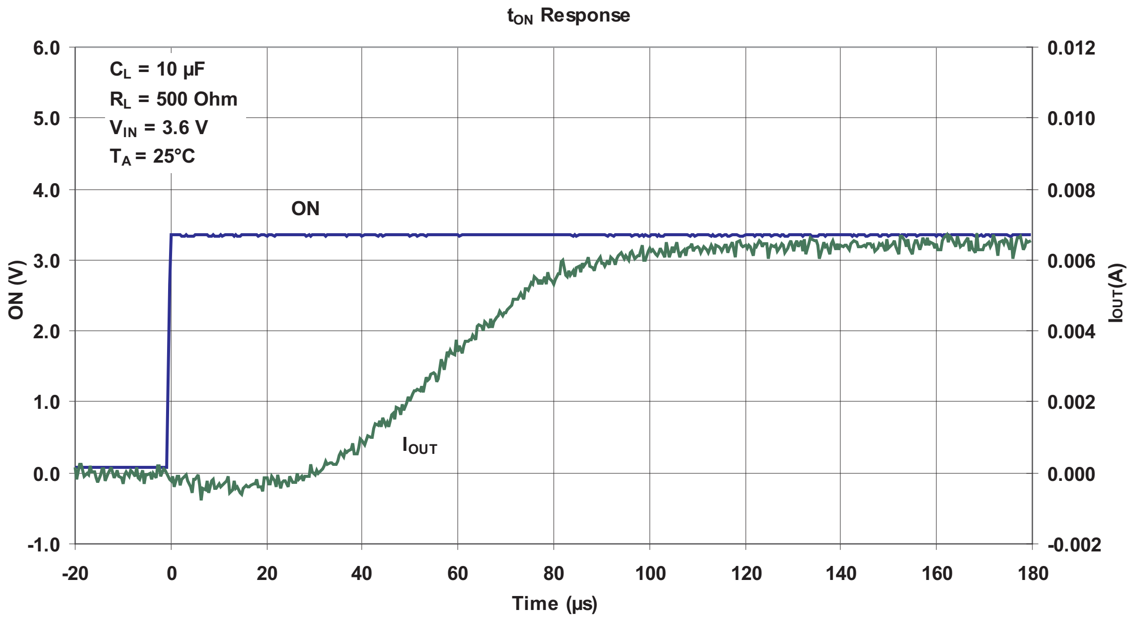

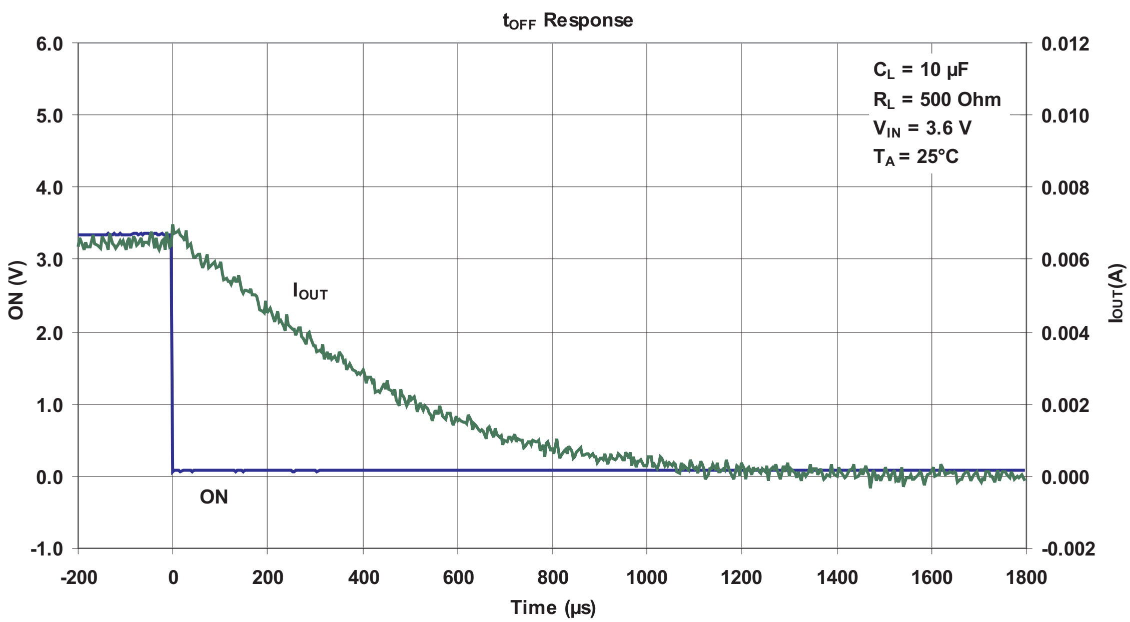

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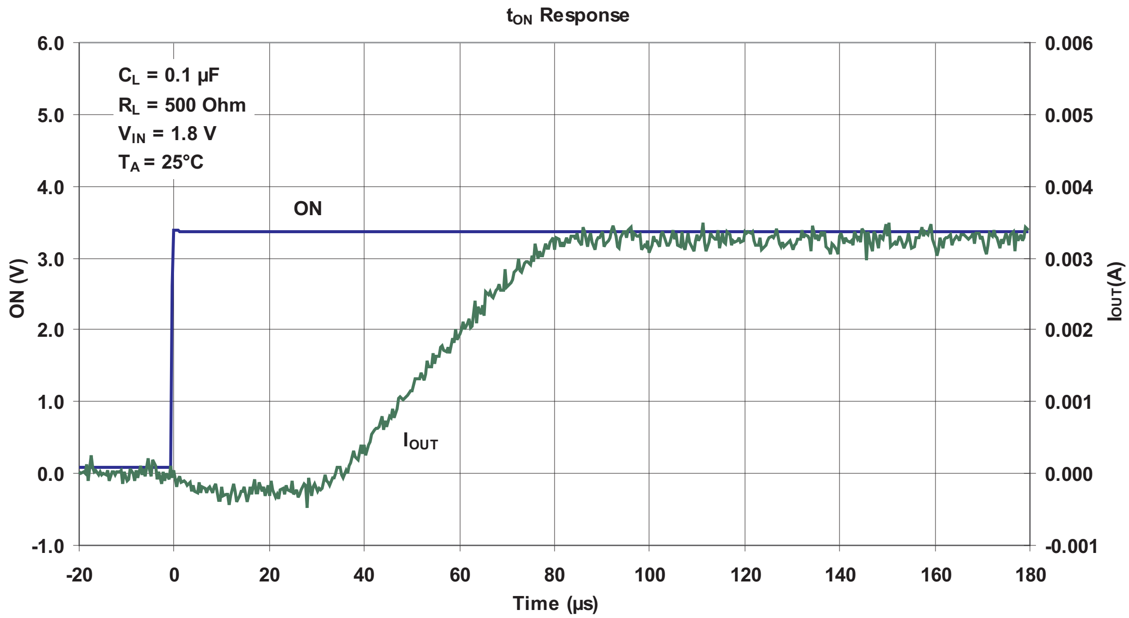

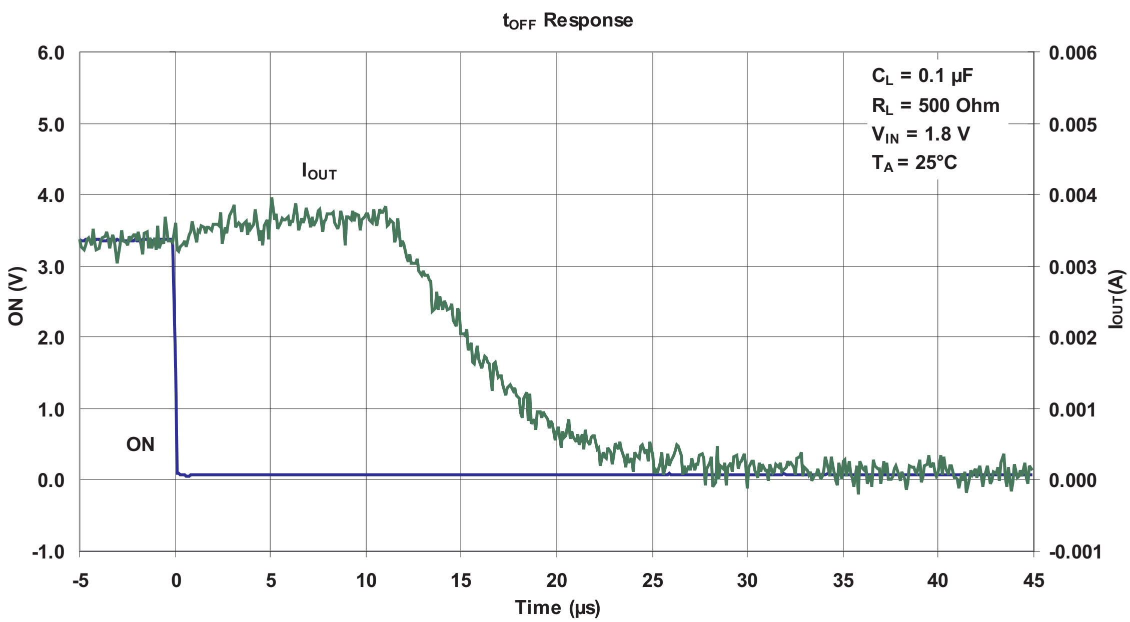

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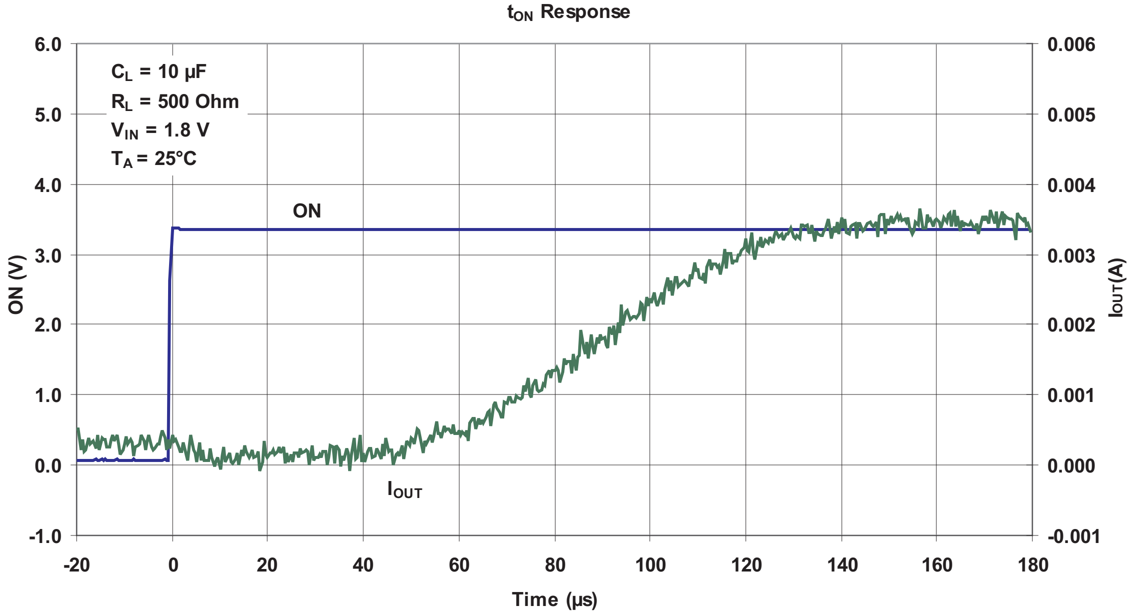

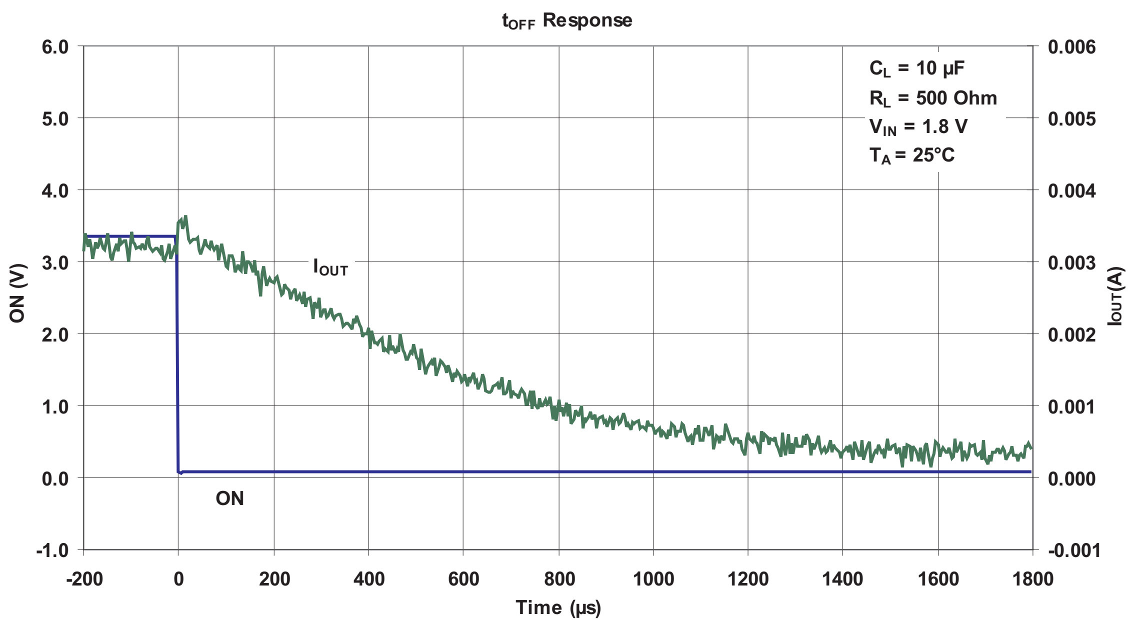

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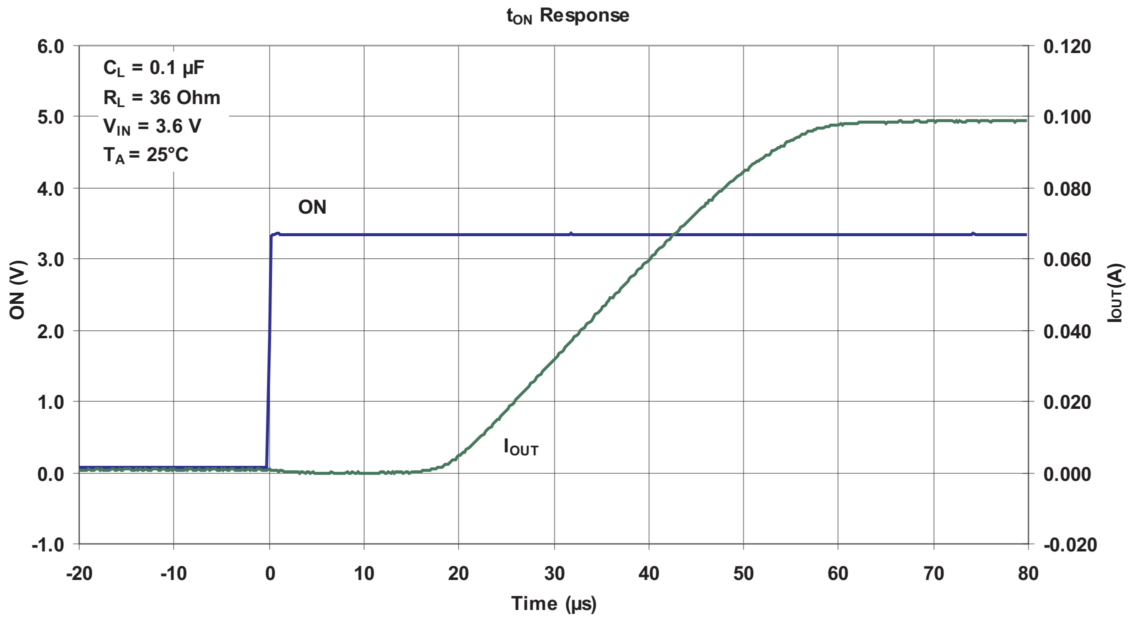

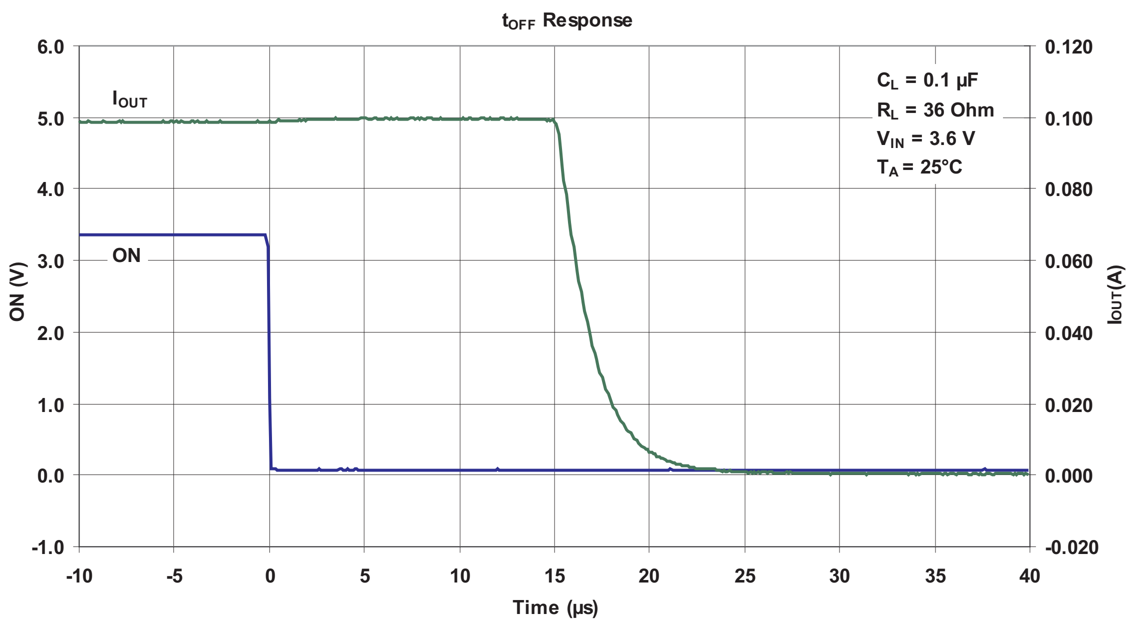

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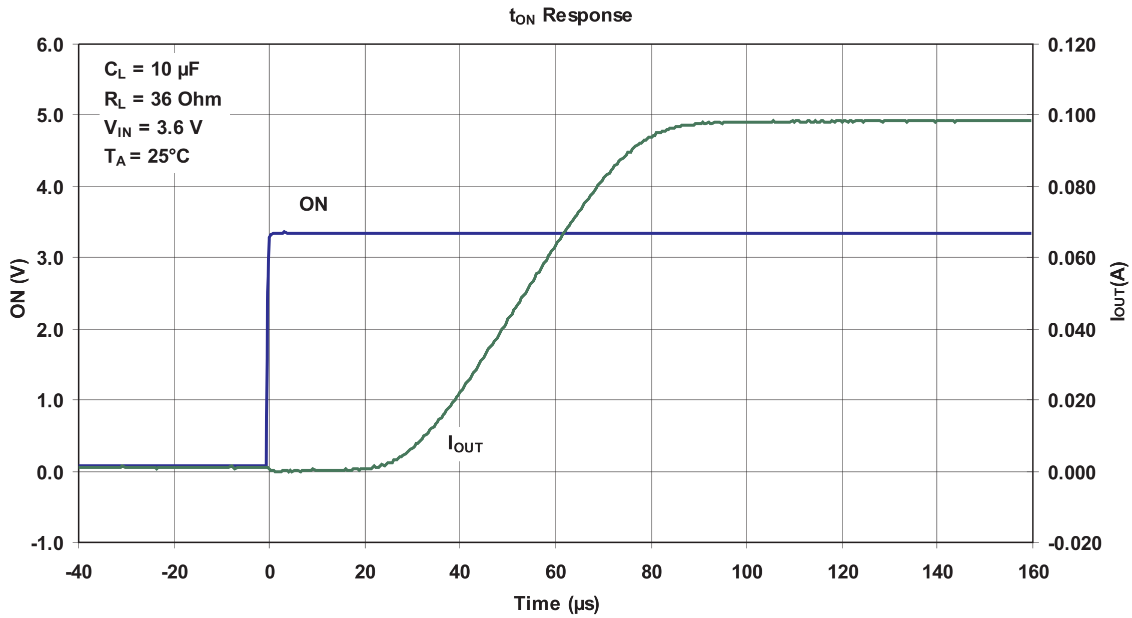

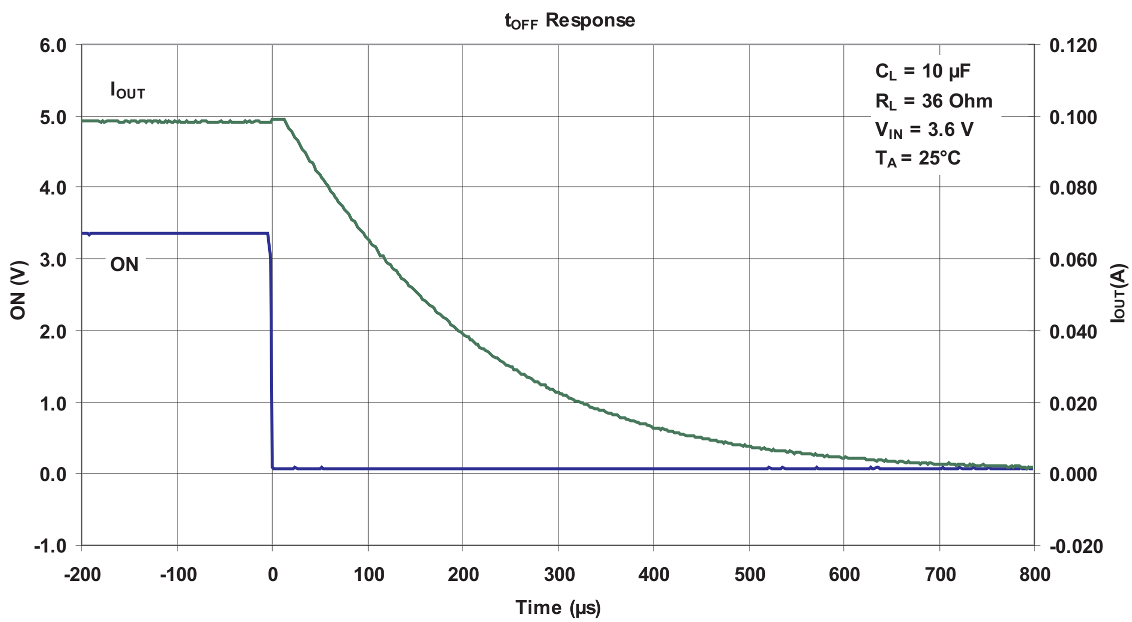

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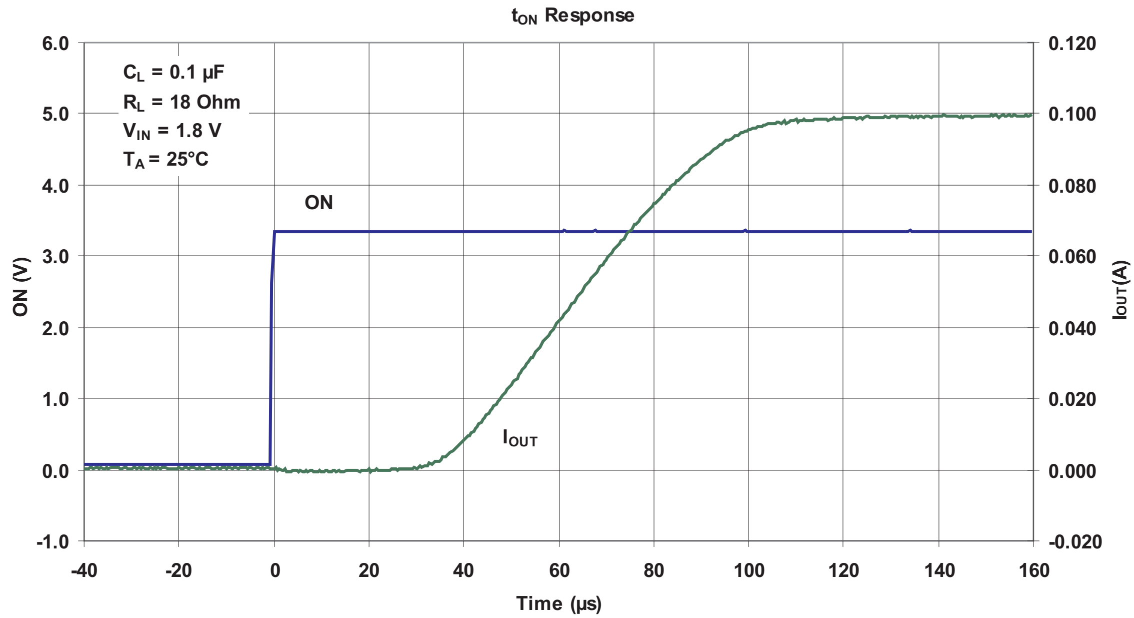
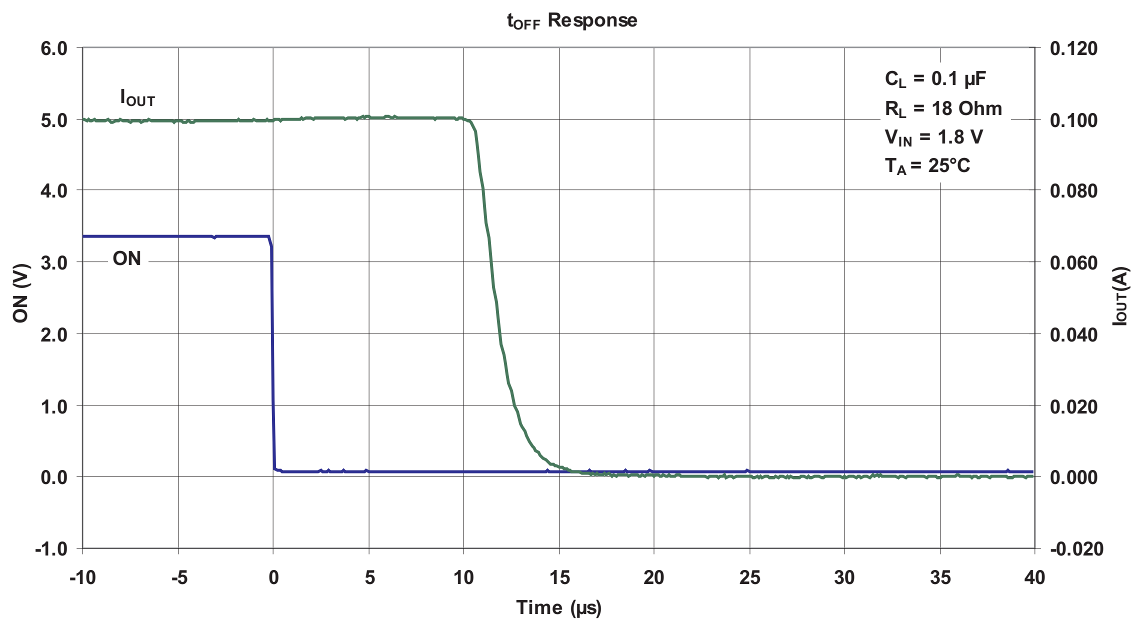
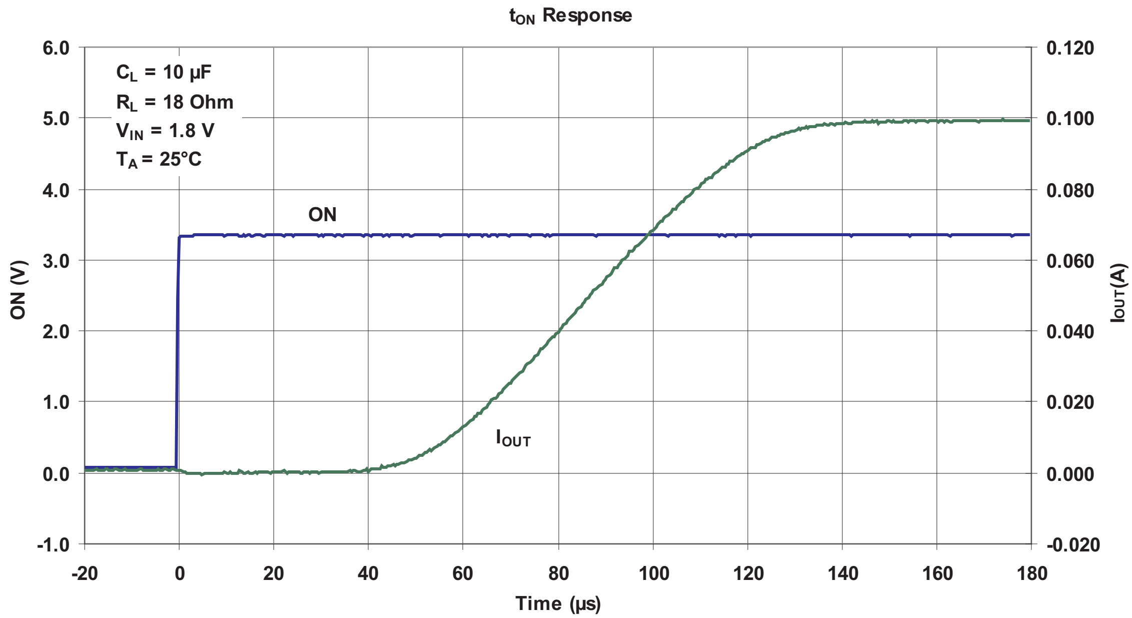
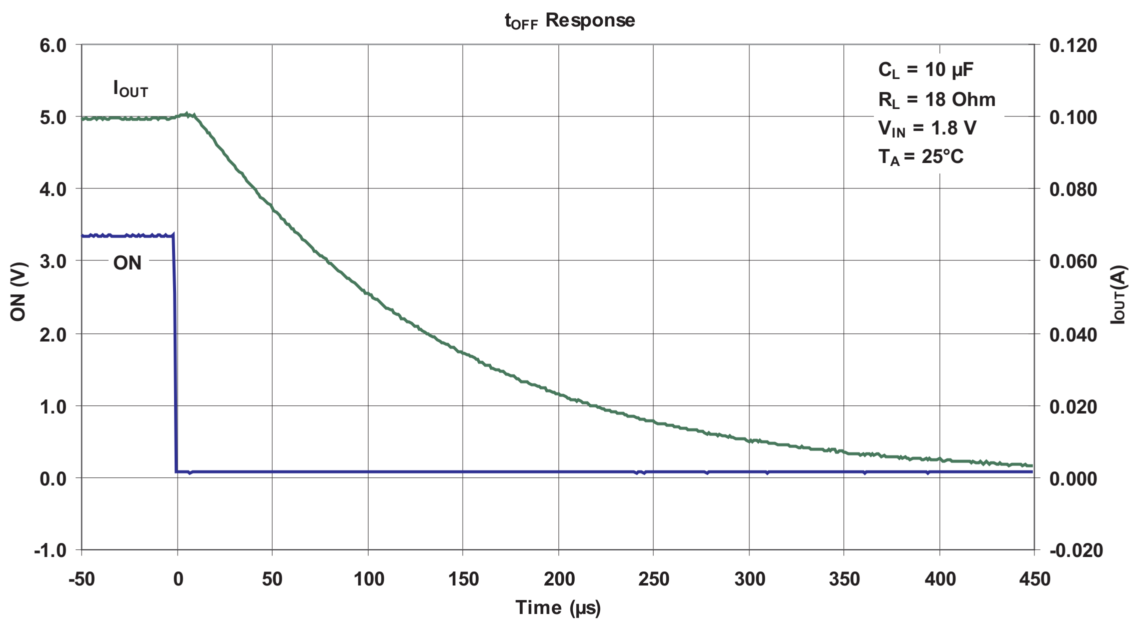




TYPICAL CHARACTERISTICS (continued)





APPLICATION INFORMATION

ON/OFF Control

The ON pin controls the state of the switch. The TPS22934 has built-in hysteresis on its control inputs. The load switch is active when the ON voltage is greater than the positive going voltage threshold (V_{TH+}). If the ON voltage is lower than the negative going voltage threshold (V_{TH-}), then the pass FET is deactivated and the active pulldown from VOUT to GND is activated.

This is ideal for power rail sequencing applications as shown in Figure 2 where the 2.8-V supply needs to be valid before the 1.8-V supply turn on:

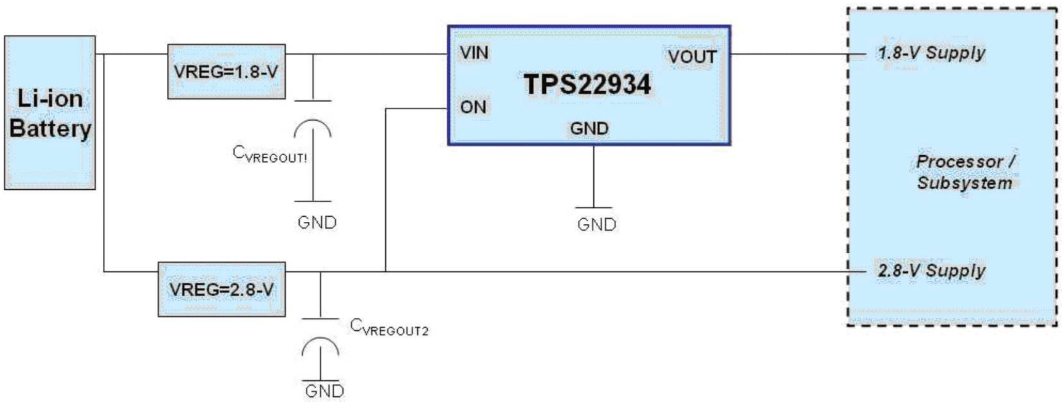


Figure 2. 1.8-V / 2.8-V Power Rail Sequencing

Input Capacitor

To limit the voltage drop on the input supply caused by transient in-rush currents when the switch turns on into a discharged load capacitor or short-circuit, a capacitor needs to be placed between VIN and GND. A 1-µF ceramic capacitor, C_{IN}, placed close to the pins is usually sufficient. Higher values of C_{IN} can be used to further reduce the voltage drop.

Output Capacitor

Due to the integral body diode in the PMOS switch, a C_{IN} greater than C_L is highly recommended. A C_L greater than C_{IN} can cause V_{OUT} to exceed V_{IN} when the system supply is removed. This could result in current flow through the body diode from V_{OUT} to V_{IN}.

Board Layout

For best performance, all traces should be as short as possible. To be most effective, the input and output capacitors should be placed close to the device to minimize the effects that parasitic trace inductances may have on normal and short-circuit operation. Using wide traces for V_{IN}, V_{OUT}, and GND helps minimize the parasitic electrical effects along with minimizing the case to ambient thermal impedance.

Undervoltage Lockout

The undervoltage lockout turns off the switch if the input voltage drops below the under-voltage lockout threshold. With the ON pin active, the input voltage rising above the undervoltage lockout threshold causes a controlled turn-on of the switch, which limits current overshoots.

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Top-Side Markings (4)	Samples
TPS22934YZVR	ACTIVE	DSBGA	YZV	4	3000	Green (RoHS & no Sb/Br)	SNAGCU	Level-1-260C-UNLIM	-40 to 85	62 N	Samples
TPS22934YZVT	ACTIVE	DSBGA	YZV	4	250	Green (RoHS & no Sb/Br)	SNAGCU	Level-1-260C-UNLIM	-40 to 85	62 N	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) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

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

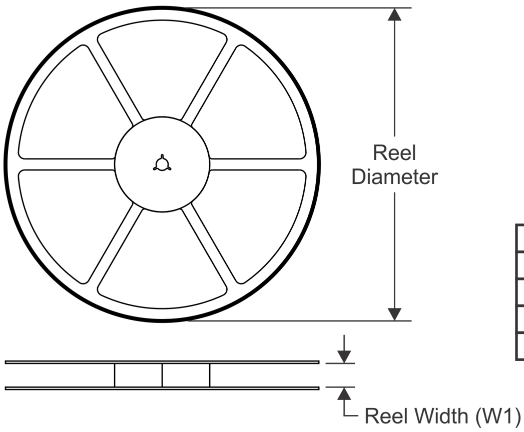
(4) Multiple Top-Side Markings will be inside parentheses. Only one Top-Side Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Top-Side Marking for that device.

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.

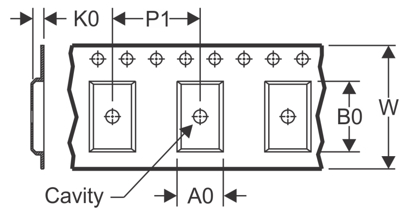
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

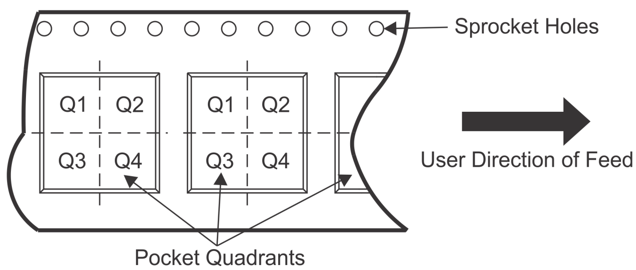


TAPE DIMENSIONS



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

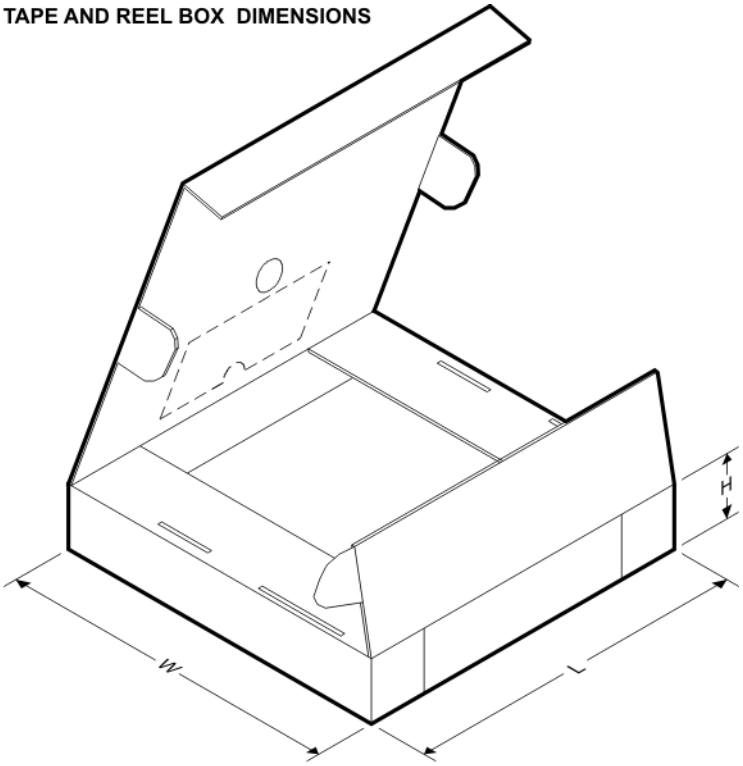
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
TPS22934YZVR	DSBGA	YZV	4	3000	178.0	9.2	1.0	1.0	0.63	4.0	8.0	Q1
TPS22934YZVT	DSBGA	YZV	4	250	178.0	9.2	1.0	1.0	0.63	4.0	8.0	Q1

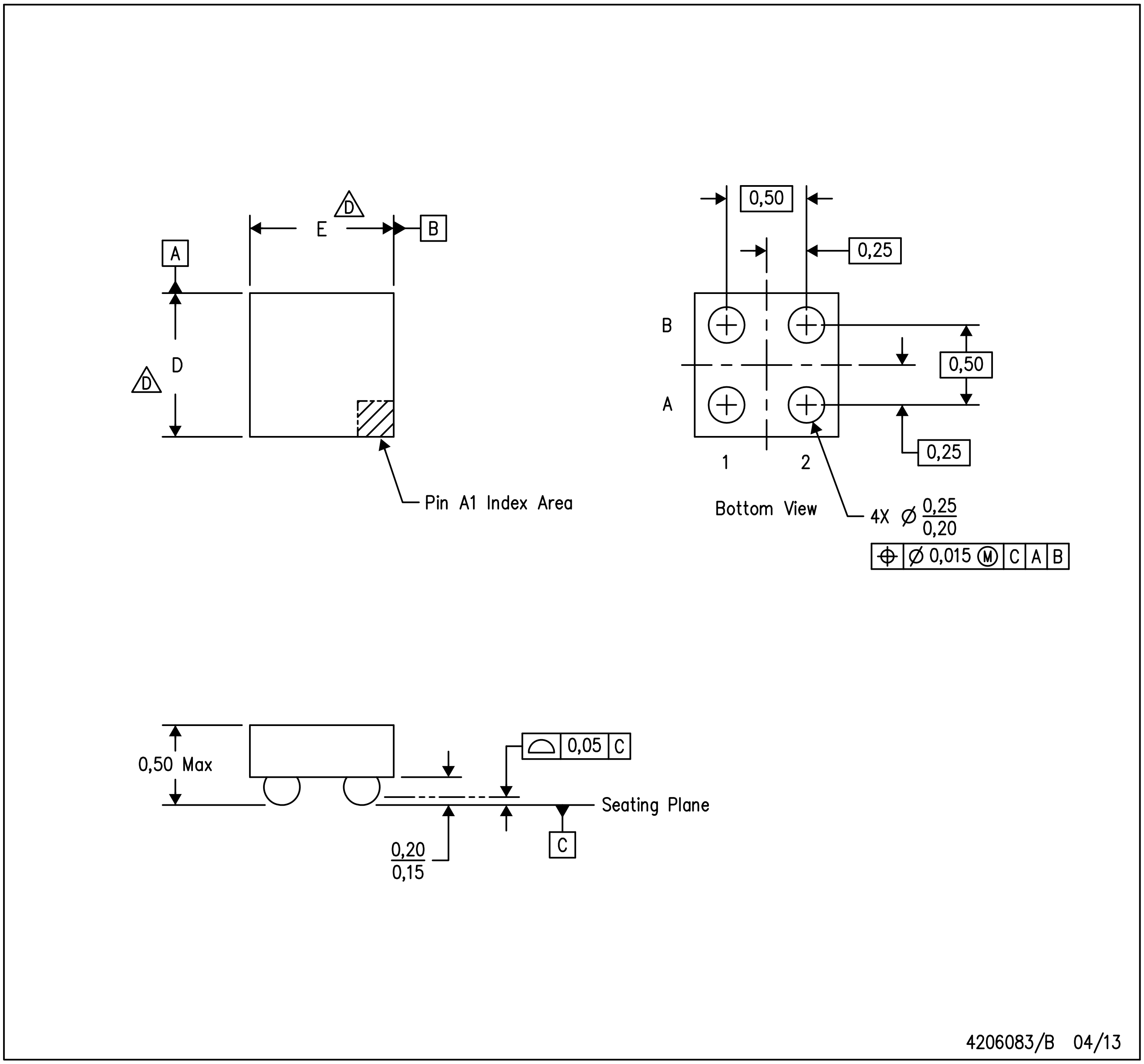
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TPS22934YZVR	DSBGA	YZV	4	3000	220.0	220.0	35.0
TPS22934YZVT	DSBGA	YZV	4	250	220.0	220.0	35.0

YZV (S–XBGA–N4) DIE–SIZE BALL GRID ARRAY



NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. NanoFree™ package configuration.
D. The package size (Dimension D and E) of a particular device is specified in the device Product Data Sheet version of this drawing, in case it cannot be found in the product data sheet please contact a local TI representative.
E. Reference Product Data Sheet for array population.
2 x 2 matrix pattern is shown for illustration only.
F. This package contains Pb–free balls. Refer to the 4 YEV package (drawing 4206082) for tin–lead (SnPb) balls.

NanoFree is a trademark of Texas Instruments.