

TPS3610U18, TPS3610T50 BATTERY-BACKUP SUPERVISORS FOR RAM RETENTION

SLVS327B – DECEMBER 2000 – REVISED DECEMBER 2002

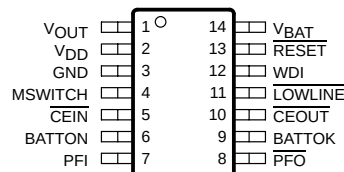
features

- Supply Current of 40 μ A (Max)
- Battery Supply Current of 100 nA (Max)
- Precision Supply-Voltage Monitor, 1.8 V, 5 V; Other Options on Request
- Watchdog Timer With 800-ms Time-Out
- Backup-Battery Voltage Can Exceed V_{DD}
- Power-On Reset Generator With Fixed 100-ms Reset Delay Time
- Battery-OK Output
- Voltage Monitor for Power-Fail or Low-Battery Monitoring
- Manual Switchover to Battery-Backup Mode
- Chip-Enable Gating . . . 3 ns (at $V_{DD} = 5$ V)
Max Propagation Delay
- Battery-Freshness Seal
- 14-pin TSSOP Package
- Temperature Range . . . -40°C to 85°C

typical applications

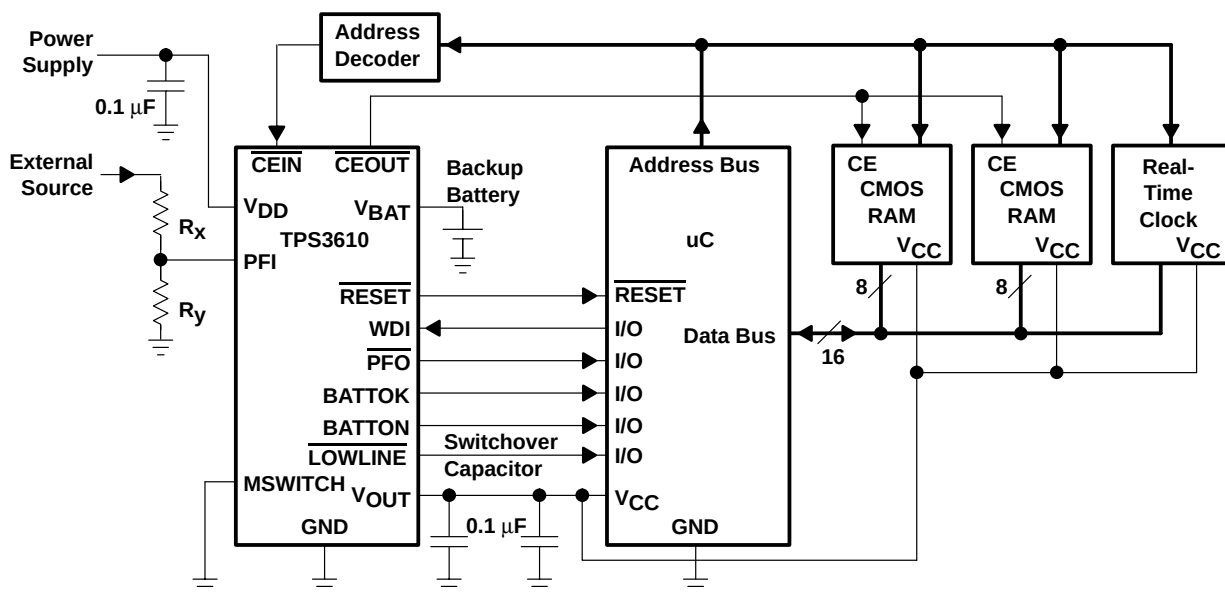
- Fax Machines
- Set-Top Boxes
- Advanced Voice Mail Systems
- Portable Battery-Powered Equipment
- Computer Equipment
- Advanced Modems
- Automotive Systems
- Portable Long-Time Monitoring Equipment
- Point of Sale Equipment

TPS3610
TSSOP (PW) Package
(TOP VIEW)



ACTUAL SIZE
(5,10mm x 6,60mm)

typical operating circuit



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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.

**TEXAS
INSTRUMENTS**

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BATTERY-BACKUP SUPERVISORS FOR RAM RETENTION

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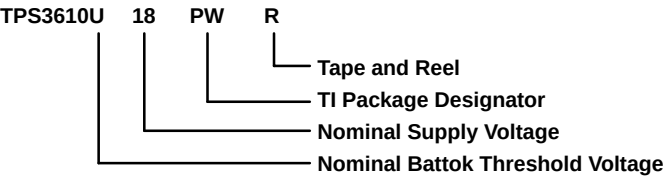
description

The TPS3610 family of supervisory circuits monitors and controls processor activity by providing backup-battery switchover for data retention of CMOS RAM. Other features include an additional power-fail comparator, low-line indication, watchdog function, battery-status indicator, manual switchover, and write protection for CMOS RAM.

The TPS3610 family allow usage of 3-V or 3.6-V lithium batteries as the backup supply in systems with, e.g., VDD = 1.8 V. During power-on, RESET is asserted when the supply voltage (VDD or VBAT) becomes higher than 1.1 V. Thereafter, the supply-voltage supervisor monitors VDD and keeps RESET output active as long as VDD remains below the threshold voltage VIT. An internal timer delays the return of the output to the inactive state (high) to ensure proper system reset. The delay time starts after VDD has risen above the threshold voltage VIT. When the supply voltage drops below the threshold voltage VIT, the output becomes active (low) again.

The product spectrum is designed for supply voltages of 1.8 V and 5 V. The circuits are available in a 14-pin TSSOP package. TPS3610 devices are characterized for operation over a temperature range of -40°C to 85°C.

standard and application-specific versions (see Note 1)



APPLICATION-SPECIFIC VERSIONS, NOMINAL SUPPLY AND BATTOK VOLTAGE			
TA	NOMINAL SUPPLY VOLTAGE, VDD(NOM) (V)	NOMINAL BATTOK THRESHOLD VOLTAGE, VIT(BOK) (V)	PACKAGED DEVICES TSSOP (PW)†
-40°C to 85°C	1.8	1.6	TPS3610U18PWR
	5	2.4	TPS3610T50PWR

† The PW package is only available taped and reeled (indicated by the R suffix on the device type).
NOTE 1: For other NOMINAL and BATTOK voltage versions, contact your local TI sales office for availability and order lead time.

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BATTERY-BACKUP SUPERVISORS FOR RAM RETENTION

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TRUTH TABLES

INPUTS				OUTPUTS				
$V_{DD} > V_{LL}$	$V_{DD} > V_{IT}$	$V_{DD} > V_{BAT}$	MSWITCH	V_{OUT}	BATTON	$\overline{LOWLINE}$	$\overline{RESET}$	$\overline{CEOUT}$
0	0	0	0	V _{BAT}	1	0	0	DIS
0	0	0	0	V _{BAT}	1	0	0	DIS
0	0	0	1	V _{BAT}	1	0	0	DIS
0	0	0	1	V _{BAT}	1	0	0	DIS
0	0	1	0	V _{DD}	0	0	0	DIS
0	0	1	0	V _{DD}	0	0	0	DIS
0	0	1	1	V _{BAT}	1	0	0	DIS
0	0	1	1	V _{BAT}	1	0	0	DIS
0	1	0	0	V _{DD}	0	0	1	DIS
0	1	0	0	V _{DD}	0	0	1	EN
0	1	0	1	V _{BAT}	1	0	1	DIS
0	1	0	1	V _{BAT}	1	0	1	EN
0	1	1	0	V _{DD}	0	0	1	DIS
0	1	1	0	V _{DD}	0	0	1	EN
0	1	1	1	V _{BAT}	1	0	1	DIS
0	1	1	1	V _{BAT}	1	0	1	EN
1	1	0	0	V _{DD}	0	1	1	DIS
1	1	0	0	V _{DD}	0	1	1	EN
1	1	0	1	V _{BAT}	1	1	1	DIS
1	1	0	1	V _{BAT}	1	1	1	EN
1	1	1	0	V _{DD}	0	1	1	DIS
1	1	1	0	V _{DD}	0	1	1	EN
1	1	1	1	V _{BAT}	1	1	1	DIS
1	1	1	1	V _{BAT}	1	1	1	EN

BAT TOK		POWER-FAIL		CHIP-ENABLE	
$V_{BAT} > V_{BOK}$	BAT TOK	$PFI > V_{(PFI)}$	$\overline{PFO}$	$\overline{CEIN}$	$\overline{CEOUT}$
0	0	0	0	0	0
1	1	1	1	1	1

Condition: $V_{DD} > V_{IT}$

Condition: $V_{DD} > V_{DDmin}$

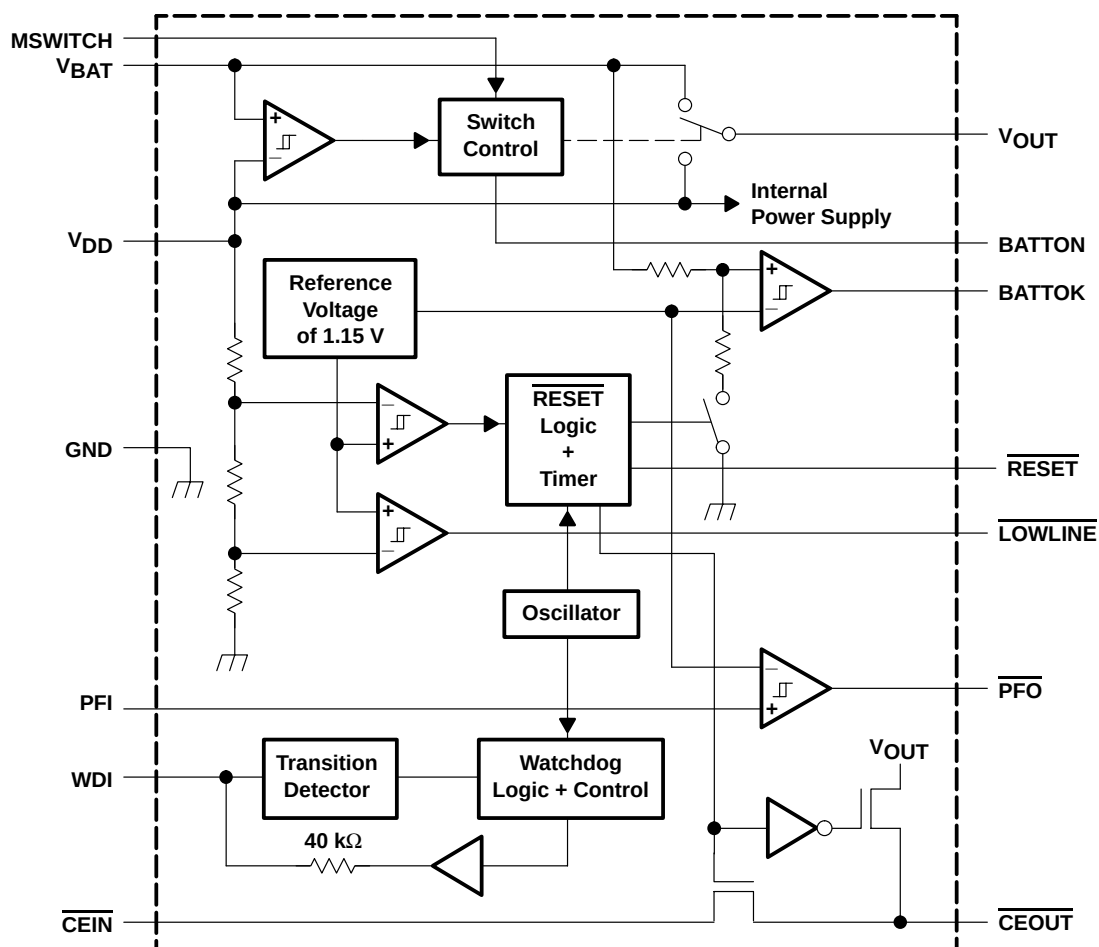
Condition: Enabled



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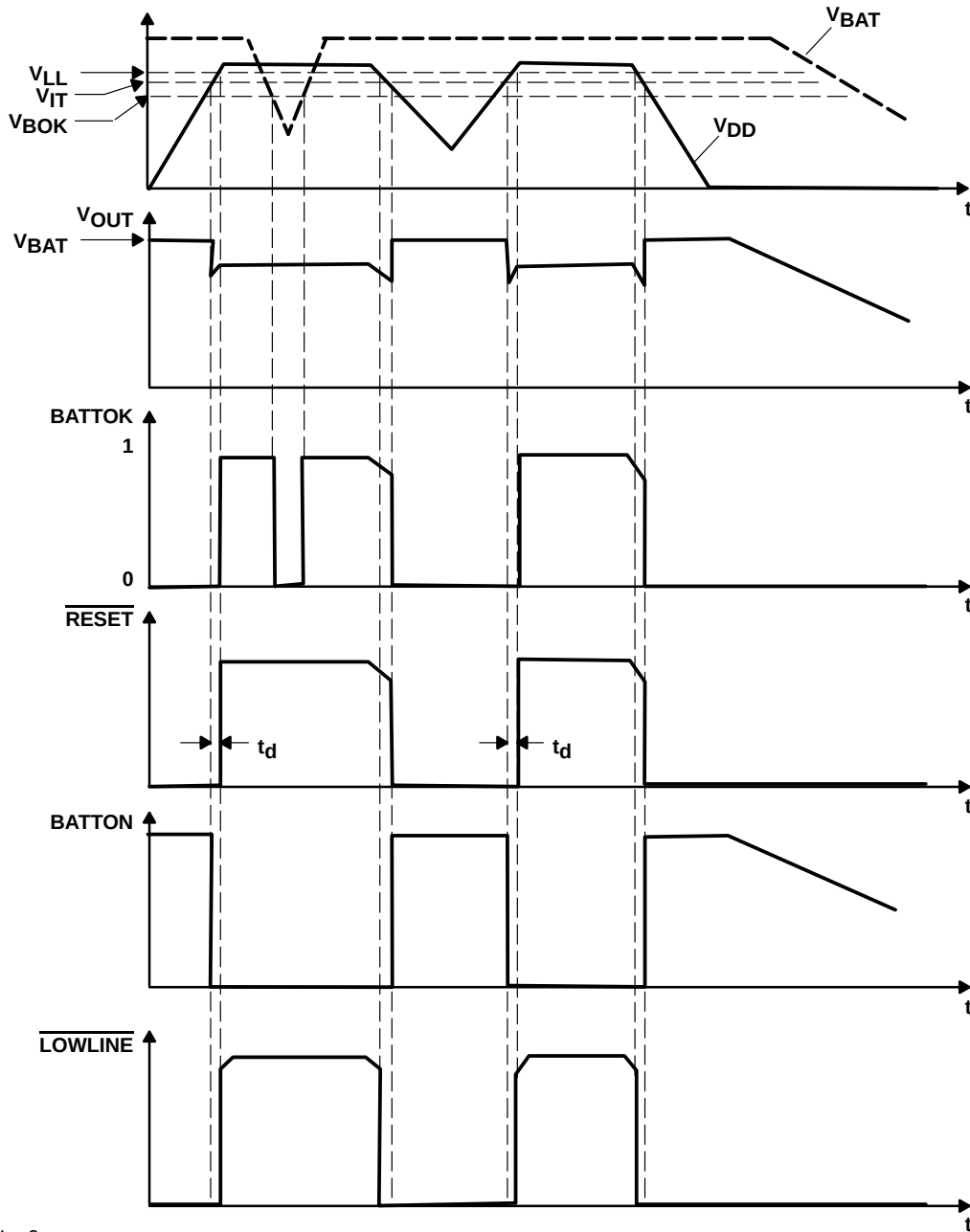
functional block diagram



TPS3610U18, TPS3610T50 BATTERY-BACKUP SUPERVISORS FOR RAM RETENTION

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timing diagram



[†] MSWITCH = 0

Timing diagram shown under operation, not in freshness seal mode.

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Terminal Functions

TERMINAL NAME	NO.	I/O	DESCRIPTION
BATTOK	9	O	Battery status output
BATTON	6	O	Logic output/external bypass switch driver output
$\overline{\text{CEIN}}$	5	I	Chip-enable input
$\overline{\text{CEOUT}}$	10	O	Chip-enable output
GND	3	I	Ground
$\overline{\text{LOWLINE}}$	11	O	Early power-fail warning output
MSWITCH	4	I	Manual switch to force device into battery-backup mode
V_{OUT}	1	O	Supply output
PFI	7	I	Power-fail comparator input
$\overline{\text{PFO}}$	8	O	Power-fail comparator output
$\overline{\text{RESET}}$	13	O	Active-low reset output
V_{BAT}	14	I	Backup-battery input
V_{DD}	2	I	Input supply voltage
WDI	12	I	Watchdog timer input

detailed description

battery freshness seal

The battery freshness seal of the TPS3610 family disconnects the backup battery from internal circuitry until it is needed. This function ensures that the backup battery connected to V_{BAT} is fresh when the final product is put to use. The following steps explain how to enable the freshness seal mode:

1. Connect V_{BAT} ($\text{V}_{\text{BAT}} > \text{V}_{\text{BATmin}}$)
2. Ground $\overline{\text{PFO}}$
3. Connect PFI to V_{DD} ($\text{PFI} = \text{V}_{\text{DD}}$)
4. Connect V_{DD} to power supply ($\text{V}_{\text{DD}} > \text{V}_{\text{IT}}$) and keep connected for $5 \text{ ms} < t < 35 \text{ ms}$

The battery freshness seal mode is disabled by the positive-going edge of $\overline{\text{RESET}}$ when V_{DD} is applied.

BATTOK output

BATTOK is a logic feedback of the device to indicate the status of the backup battery. The supervisor checks the battery voltage every 200 ms with a voltage divider load of approximately 100 k Ω and a measurement cycle on-time of 25 μs . The measurement cycle starts after the reset is released. If the battery voltage V_{BAT} is below the negative-going threshold voltage $\text{V}_{\text{IT(BOK)}}$, the indicator BATTOK does a high-to-low transition. Otherwise it retains its status to V_{DD} level.

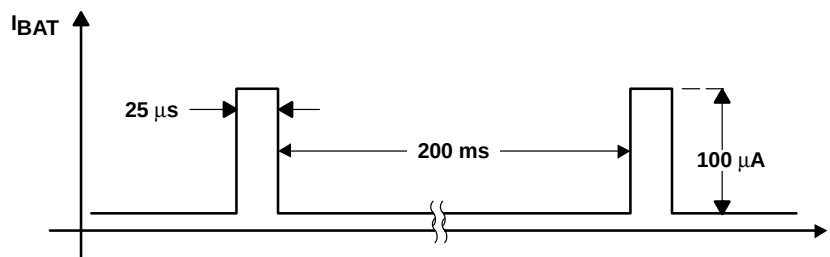


Figure 1. BATTOK Timing



detailed description (continued)

chip-enable signal gating

The internal gating of chip-enable signals, CE, prevents erroneous data from corrupting CMOS RAM during an undervoltage condition. The TPS3610 use a series transmission gate from $\overline{\text{CEIN}}$ to $\overline{\text{CEOUT}}$. During normal operation (reset not asserted), the CE transmission gate is enabled and passes all CE transitions. When reset is asserted, this path becomes disabled, preventing erroneous data from corrupting the CMOS RAM. The short CE propagation delay from $\overline{\text{CEIN}}$ to $\overline{\text{CEOUT}}$ enables TPS3610 devices to be used with most processors.

The CE transmission gate is disabled and $\overline{\text{CEIN}}$ is high-impedance (disable mode) while reset is asserted. During a power-down sequence, when V_{DD} crosses the reset threshold, the CE transmission gate is disabled and $\overline{\text{CEIN}}$ immediately becomes high impedance if the voltage at $\overline{\text{CEIN}}$ is high. If $\overline{\text{CEIN}}$ is low while reset is asserted, the CE transmission gate is disabled at the same time $\overline{\text{CEIN}}$ goes high, or 15 μs after $\overline{\text{RESET}}$ asserts, whichever occurs first. This allows the current write cycle to complete during power-down. When the CE transmission gate is enabled, the impedance of $\overline{\text{CEIN}}$ appears as a resistor in series with the load at $\overline{\text{CEOUT}}$. The overall device propagation delay through the CE transmission gate depends on V_{OUT} , the source impedance of the device connected to $\overline{\text{CEIN}}$ and the load at $\overline{\text{CEOUT}}$. To achieve minimum propagation delay, the capacitive load at $\overline{\text{CEOUT}}$ should be minimized, and a low-output-impedance driver should be used.

During disable mode, the transmission gate is off and an active pullup connects $\overline{\text{CEOUT}}$ to V_{OUT} . The pullup turns off when the transmission gate is enabled.

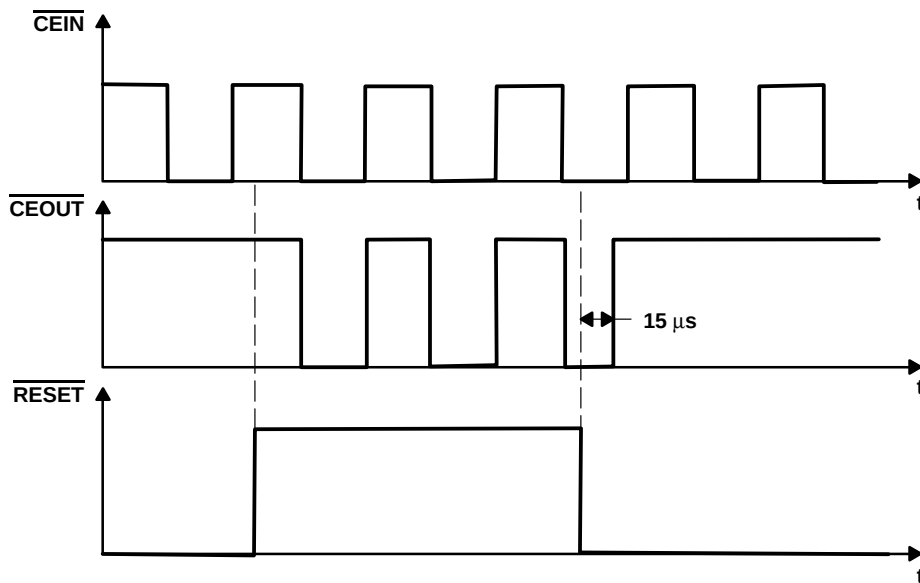


Figure 2. Chip-Enable Timing

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detailed description (continued)

power-fail comparator (PFI and $\overline{\text{PFO}}$)

An additional comparator is provided to monitor voltages other than the nominal supply voltage. The power-fail-input (PFI) is compared with an internal voltage reference of 1.15 V. If the input voltage falls below the power-fail threshold $V_{\text{IT(PFI)}}$ of typical 1.15 V, the power-fail output ($\overline{\text{PFO}}$) goes low. If $V_{\text{IT(PFI)}}$ goes above $V_{\text{(PFI)}}$, plus about 12-mV hysteresis, the output returns to high. By connecting two external resistors, it is possible to supervise any voltages above $V_{\text{(PFI)}}$. The sum of both resistors should be about 1 M Ω , to minimize power consumption and also to assure that the current in the PFI pin can be neglected compared with the current through the resistor network. The tolerance of the external resistors should be not more than 1% to ensure minimal variation of sensed voltage. If the power-fail comparator is unused, PFI should be connected to ground and $\overline{\text{PFO}}$ left unconnected.

LOWLINE

The lowline comparator monitors V_{DD} with a threshold voltage typically 2% above the reset threshold (V_{IT}). For normal operation (V_{DD} above the reset threshold), $\overline{\text{LOWLINE}}$ is pulled to V_{DD} . $\overline{\text{LOWLINE}}$ can be used to provide a nonmaskable interrupt (NMI) to the processor when power begins to fall. In most battery-operated portable systems, reserve energy in the battery provides enough time to complete the shutdown routine once the low-line warning is encountered and before reset asserts. If the system must also contend with a more rapid V_{DD} fall time, such as when the main battery is disconnected or a high-side switch is opened during normal operation, a capacitor can be used on the V_{DD} line to provide enough time for executing the shutdown routine. First, the worst-case settling time (t_{sd}) required for the system to perform its shutdown routine needs to be defined. Then, using the worst-case load current (I_{L}) that can be drained from the capacitor, and the minimum reset threshold voltage (V_{ITmin}), the capacitor value (C_{H}) can be calculated as follows:

$$C_{\text{H}} = \frac{I_{\text{L}} \times t_{\text{sd}}}{V_{\text{ITmin}} \times 0.012}$$

BATTON

Most often BATTON is used as a gate drive for an external pass transistor for high-current applications. In addition, it can be used as a logic output to indicate the battery switchover status. BATTON is high when V_{OUT} is connected to V_{BAT} .

BATTON can be connected directly to the gate of a PMOS transistor (see Figure 3). No current-limiting resistor is required. If a PMOS transistor is used, it must be connected in the reverse of the traditional method (see Figure 3), which orients the body diode from V_{DD} to V_{OUT} and prevents the backup battery from discharging through the FET when its gate is high.

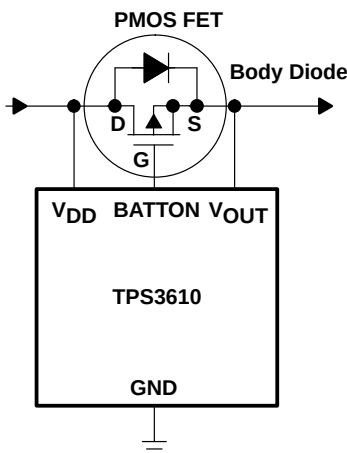


Figure 3. Driving an External MOSFET Transistor With BATTON

detailed description (continued)

backup-battery switchover

In case of a brownout or power failure, it may be necessary to preserve the contents of RAM. If a backup-battery is installed at V_{BAT} , the device automatically switches the connected RAM to backup power when V_{DD} fails. In order to allow the backup-battery (e.g., a 3.6-V lithium cell) to have a higher voltage than V_{DD} , these supervisors do not connect V_{BAT} to V_{OUT} when V_{BAT} is greater than V_{DD} . V_{BAT} only connects to V_{OUT} (through a 15- Ω switch) when V_{DD} falls below V_{IT} and V_{BAT} is greater than V_{DD} . When V_{DD} recovers, switchover is deferred either until V_{DD} crosses V_{BAT} , or until V_{DD} rises above the reset threshold V_{IT} . V_{OUT} connects to V_{DD} through a 1- Ω (max) PMOS switch when V_{DD} crosses the reset threshold.

FUNCTION TABLE

$V_{DD} > V_{BAT}$	$V_{DD} > V_{IT}$	V_{OUT}
1	1	V_{DD}
1	0	V_{DD}
0	1	V_{DD}
0	0	V_{BAT}

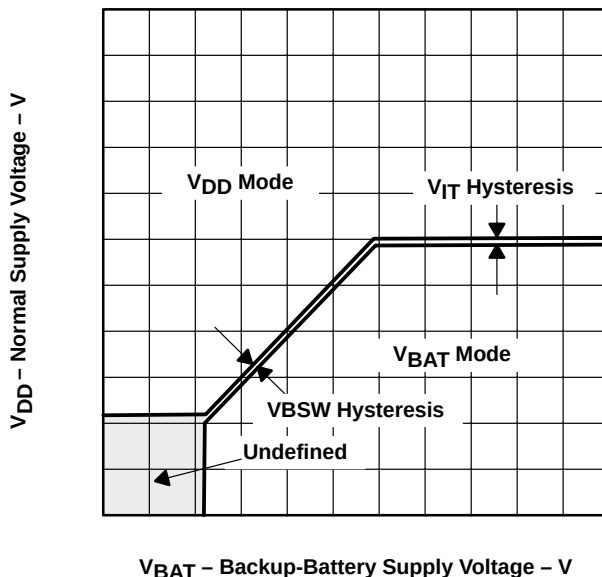


Figure 4. Normal Supply Voltage vs Backup-Battery Supply Voltage

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detailed description (continued)

manual switchover (MSWITCH)

While operating in the normal mode from V_{DD} , the device can be forced manually to operate in battery-backup mode by connecting MSWITCH to V_{DD} . Refer to Table 1 for different switchover modes.

Table 1. Switchover Modes

	MSWITCH	STATUS
V_{DD} mode	GND	V_{DD} mode
	V_{DD}	Switch to battery-backup mode
Battery-backup mode	GND	Battery-backup mode
	V_{DD}	Battery-backup mode

If the manual switchover feature is not used, MSWITCH *must* be connected to ground.

watchdog

In a microprocessor- or DSP-based system, it is important not only to supervise the supply voltage, but also to ensure correct program execution. The task of a watchdog is to ensure that the program is not stalled in an indefinite loop. The microprocessor, microcontroller or DSP has to toggle the watchdog input within typically 0.8 s to avoid the occurrence of a time-out. Either a low-to-high or a high-to-low transition resets the internal watchdog timer. If the input is unconnected, the watchdog is disabled and is retriggered internally.

saving current while using the watchdog

The watchdog input is internally driven low during the first 7/8 of the watchdog time-out period, then the input momentarily pulses high, resetting the watchdog counter. For minimum watchdog input current (minimum overall power consumption), WDI should be left low for the majority of the watchdog time-out period, and pulsed low-high-low once within 7/8 of the watchdog time-out period to reset the watchdog timer. If instead WDI is externally driven high for the majority of the timeout period, a current of, e.g., $5\text{ V}/40\text{ k}\Omega \approx 125\text{ }\mu\text{A}$, can flow into WDI.

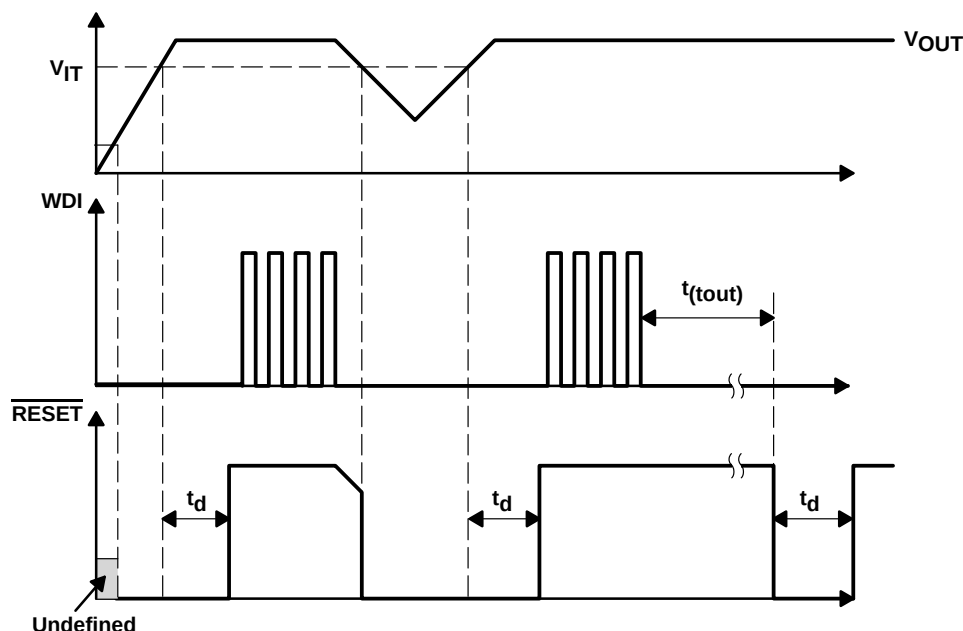


Figure 5. Watchdog Timing

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

Supply voltage, V_{DD} (see Note 2)	7 V
All other pins (see Note 2)	–0.3 V to 7 V
Continuous output current at V_{OUT} , $I_{O(VOUT)}$	400 mA
Continuous output current (all other pins) I_O	±10 mA
Continuous total power dissipation	See Dissipation Rating Table
Operating free-air temperature range, T_A	–40°C to 85°C
Storage temperature range, T_{Stg}	–65°C to 150°C
Lead temperature soldering 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.

NOTE 2: All voltage values are with respect to GND. For reliable operation the device must not be operated at 7 V for more than $t=1000h$ continuously.

DISSIPATION RATING TABLE

PACKAGE	$T_A \leq 25^\circ\text{C}$ POWER RATING	DERATING FACTOR ABOVE $T_A = 25^\circ\text{C}$	$T_A = 70^\circ\text{C}$ POWER RATING	$T_A = 85^\circ\text{C}$ POWER RATING
PW	700 mW	5.6 mW/°C	448 mW	364 mW

recommended operating conditions

	MIN	MAX	UNIT
Supply voltage, V_{DD}	1.65	5.5	V
Battery supply voltage, V_{BAT}	1.5	5.5	V
Input voltage, V_I	0	$V_{DD}+0.3$	V
High-level input voltage, V_{IH}	$0.7 \times V_{DD}$		V
Low-level input voltage, V_{IL}		$0.3 \times V_{DD}$	V
Continuous output current at V_{OUT} , I_O		300	mA
Input transition rise and fall rate at WDI, MSWITCH, $\Delta t/\Delta V$		100	ns/V
Slew rate at V_{DD} or V_{BAT}		1	V/μs
Operating free-air temperature range, T_A	–40	85	°C



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electrical characteristics over recommended operating free-air temperature range (unless otherwise noted)

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
V _{OH}	High-level output voltage	<u>RESET</u> , BATTOK	V _{DD} = 1.8 V, I _{OH} = –400 μA	V _{DD} –0.2 V		V	
			V _{DD} = 3.3 V, I _{OH} = –2 mA	V _{DD} –0.4 V			
			V _{DD} = 5 V, I _{OH} = –3 mA	V _{DD} –0.4 V			
		BATTON	V _{OUT} = 1.8 V, I _{OH} = –400 μA	V _{OUT} –0.2 V			
			V _{OUT} = 3.3 V, I _{OH} = –2 mA	V _{OUT} –0.4 V			
			V _{OUT} = 5 V, I _{OH} = –3 mA	V _{OUT} –0.4 V			
		<u>LOWLINE</u> , PFO	V _{DD} = 1.8 V, I _{OH} = –20 μA	V _{DD} –0.3 V			
			V _{DD} = 3.3 V, I _{OH} = –80 μA,	V _{DD} –0.4 V			
			V _{DD} = 5 V, I _{OH} = –120 μA	V _{DD} –0.4 V			
	<u>CEOUT</u> , Enable mode, CEIN = V _{OUT}	V _{OUT} = 1.8 V, I _{OH} = –1 mA	V _{OUT} –0.2 V				
		V _{OUT} = 3.3 V, I _{OH} = –2 mA	V _{OUT} –0.3 V				
		V _{OUT} = 5 V, I _{OH} = –5 mA	V _{OUT} –0.3 V				
<u>CEOUT</u> , Disable mode	V _{OUT} = 3.3 V, I _{OH} = –0.5 mA	V _{OUT} –0.4 V					
V _{OL}	Low-level output voltage	<u>RESET</u> , <u>PFO</u> , BATTOK, LOWLINE	V _{DD} = 1.8 V, I _{OL} = 400 μA			0.2	V
			V _{DD} = 3.3 V, I _{OL} = 2 mA			0.4	
			V _{DD} = 5 V, I _{OL} = 3 mA			0.4	
		BATTON	V _{OUT} = 1.8 V, I _{OL} = 500 μA			0.2	
			V _{OUT} = 3.3 V, I _{OL} = 3 mA			0.4	
			V _{OUT} = 5 V, I _{OL} = 5 mA			0.4	
		<u>CEOUT</u> , Enable mode, CEIN = 0 V	V _{OUT} = 1.8 V, I _{OL} = 1 mA			0.2	
			V _{OUT} = 3.3 V, I _{OL} = 2 mA			0.3	
			V _{OUT} = 5 V, I _{OL} = 5 mA			0.3	
	Power-up reset voltage (see Note 3)			I _{OL} = 20 μA, V _{BAT} > 1.1 V, OR V _{DD} > 1.1 V,			0.4
V _{OUT}	Normal mode	I _O = 8.5 mA, V _{BAT} = 0 V	V _{DD} = 1.8 V,	V _{DD} –50 mV		V	
		I _O = 125 mA, V _{BAT} = 0 V	V _{DD} = 3.3 V,	V _{DD} –150 mV			
		I _O = 200 mA, V _{BAT} = 0 V	V _{DD} = 5 V,	V _{DD} –200 mV			
	Battery-backup mode	I _O = 0.5 mA, V _{BAT} = 1.5 V	V _{DD} = 0 V,	V _{BAT} –20 mV			
		I _O = 7.5 mA, V _{BAT} = 3.3 V	V _{DD} = 0 V,	V _{BAT} –113 mV			

NOTE 3: The lowest supply voltage at which RESET becomes active. t_r, V_{DD} ≥ 15 µs/V

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electrical characteristics over recommended operating free-air temperature range (unless otherwise noted) (continued)

PARAMETER			TEST CONDITIONS		MIN	TYP	MAX	UNIT
V _{IT}	Negative-going input threshold voltage (see Note 4)	TPS3610U18	T _A = −40°C to 85°C		1.68	1.71	1.74	V
		TPS3610T50			4.46	4.55	4.64	
V(PFI)		PFI			1.13	1.15	1.17	
V(BOK)		TPS3610T50			2.33	2.4	2.47	
		TPS3610U18			1.55	1.6	1.65	
V(LL)			LOWLINE			V _{IT} +1.2%	V _{IT} +2%	V _{IT} +2.8%
V _{hys}	Hysteresis	V _{IT}	1.65 V < V _{IT} < 2.5 V		20			mV
			2.5 V < V _{IT} < 3.5 V		40			
			3.5 V < V _{IT} < 5.5 V		60			
		LOWLINE	1.65 V < V(LL) < 2.5 V		20			
			2.5 V < V(LL) < 3.5 V		40			
			3.5 V < V(LL) < 5.5 V		60			
		BAT TOK	1.65 V < V(BOK) < 2.5 V		20			
			2.5 V < V(BOK) < 3.5 V		40			
			3.5 V < V(BOK) < 5.5 V		60			
		PFI			12			
V _{BSW} (see Note 5)	V _{DD} = 1.8 V		55					
I _{IH}	High-level input current	WDI	WDI = V _{DD} = 5 V		150			μA
I _{IL}	Low-level input current	(see Note 6)	WDI = 0 V, V _{DD} = 5 V		−150			
I _I	Input current	PFI, MSWITCH			−25 25			nA
I _{OS}	Short-circuit output current	PFO	PFO = 0 V	V _{DD} = 1.8 V	−0.3			mA
				V _{DD} = 3.3 V	−1.1			
				V _{DD} = 5 V	−2.4			
I _{DD}	Supply current at V _{DD}	V _{OUT} = V _{DD}		40			μA	
		V _{OUT} = V _{BAT}		40				
I _{BAT}	Supply current at V _{BAT}	V _{OUT} = V _{DD}		−0.1 0.1			μA	
		V _{OUT} = V _{BAT}		0.5				
I _{lkg}	Leakage current at CEIN	Disable mode, V _I < V _{DD}		±1			μA	
r _{DS(on)}	V _{DD} to V _{OUT} on-resistance		V _{DD} = 5 V		0.6 1		Ω	
	V _{BAT} to V _{OUT} on-resistance		V _{BAT} = 3.3 V		8 15			
C _i	Input capacitance		V _I = 0 V to 5 V		5			pF

NOTES: 4. To ensure best stability of the threshold voltage, a bypass capacitor (ceramic, 0.1 μF) should be placed near to the supply terminals.
5. For $V_{DD} < 1.6\text{ V}$, V_{OUT} switches to V_{BAT} regardless of V_{BAT} .
6. For details on how to optimize current consumption when using WDI. Refer to detailed description section, *watchdog*.



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timing requirements at $R_L = 1\text{ M}\Omega$, $C_L = 50\text{ pF}$, $T_A = -40^\circ\text{C}$ to 85°C

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
t_W	Pulse width	At V_{DD} $V_{IH} = V_{IT} + 0.2\text{ V}$, $V_{IL} = V_{IT} - 0.2\text{ V}$	6			μs
		At WDI $V_{DD} = V_{IT} + 0.2\text{ V}$, $V_{IL} = 0.3 \times V_{DD}$, $V_{IH} = 0.7 \times V_{DD}$	100			ns

switching characteristics at $R_L = 1\text{ M}\Omega$, $C_L = 50\text{ pF}$, $T_A = -40^\circ\text{C}$ to 85°C

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
t_d	Delay time	$V_{DD} > V_{IT} + 0.2\text{ V}$	60	100	140	ms
$t_{(tout)}$	Watchdog timeout	(see timing diagram)	0.48	0.8	1.12	s
t_{PLH}	Propagation (delay) time, low-to-high-level output	50% $\overline{\text{RESET}}$ to 50% $\overline{\text{CEOUT}}$		15		μs
t_{PHL}	Propagation (delay) time, high-to-low-level output	$V_{DD} = 1.8\text{ V}$		5	15	ns
		50% $\overline{\text{CEIN}}$ to 50% $\overline{\text{CEOUT}}$, $C_L = 50\text{ pF}$ only (see Note 7)		1.6	5	
		$V_{DD} = 3.3\text{ V}$		1	3	
		V_{DD} to $\overline{\text{RESET}}$		2	5	μs
		PFI to $\overline{\text{PFO}}$		3	5	
t_t	Transition time	V_{DD} to $\overline{\text{BATTON}}$			3	μs

NOTE 7: Specified by design

TYPICAL CHARACTERISTICS

Table of Graphs

			FIGURE
$r_{DS(on)}$	Static drain-source on-state resistance (V_{DD} to V_{OUT})	vs Output current	6
	Static drain-source on-state resistance (V_{BAT} to V_{OUT})		7
	Static drain-source on-state resistance	vs Input voltage at $\overline{\text{CEIN}}$	8
I_{DD}	Supply current	vs Supply voltage	9
V_{IT}	Normalized threshold at $\overline{\text{RESET}}$	vs Free-air temperature	10
V_{OH}	High-level output voltage at $\overline{\text{RESET}}$	vs High-level output current	11, 12
	High-level output voltage at $\overline{\text{PFO}}$		13, 14
	High-level output voltage at $\overline{\text{CEOUT}}$		15, 16, 17, 18
V_{OL}	Low-level output voltage at $\overline{\text{RESET}}$	vs Low-level output current	19, 20
	Low-level output voltage at $\overline{\text{CEOUT}}$		21, 22
	Low-level output voltage at $\overline{\text{BATTON}}$		23, 24
$t_{p(min)}$	Minimum Pulse Duration at V_{DD}	vs Threshold overdrive at V_{DD}	25
$t_{p(min)}$	Minimum Pulse Duration at PFI	vs Threshold overdrive at PFI	26



TYPICAL CHARACTERISTICS

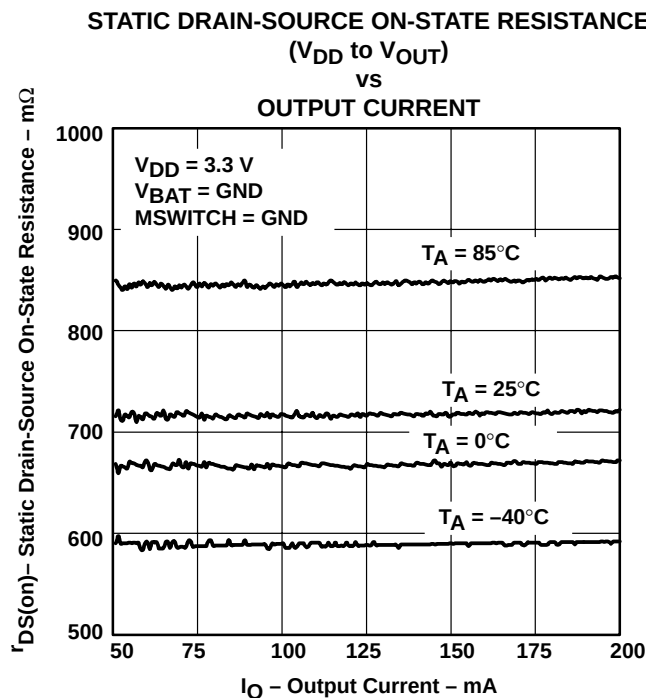


Figure 6

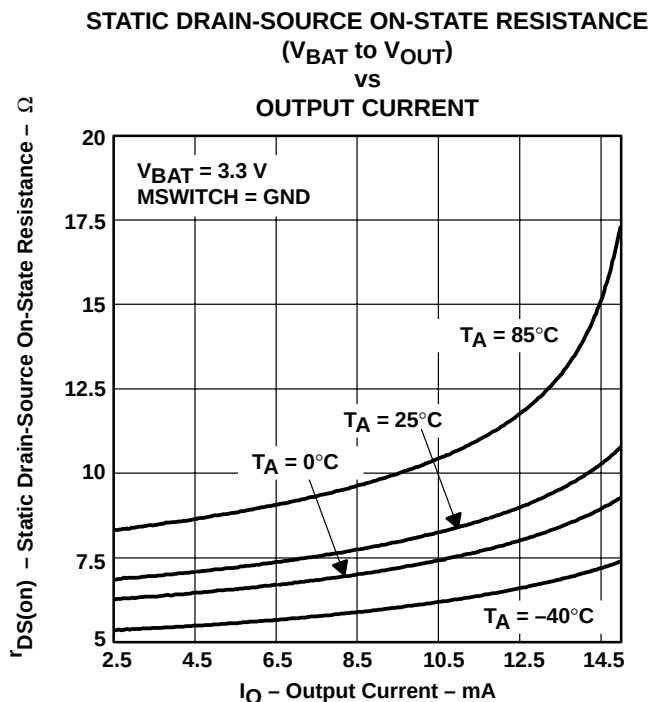


Figure 7

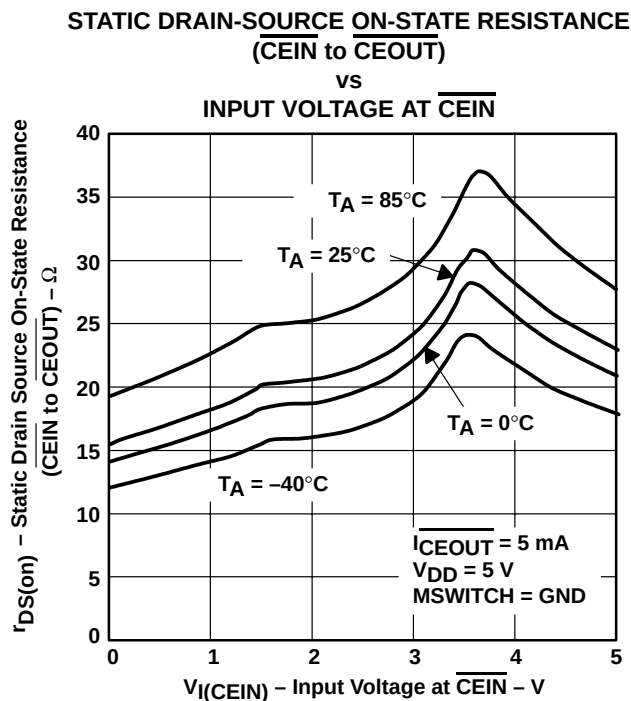


Figure 8

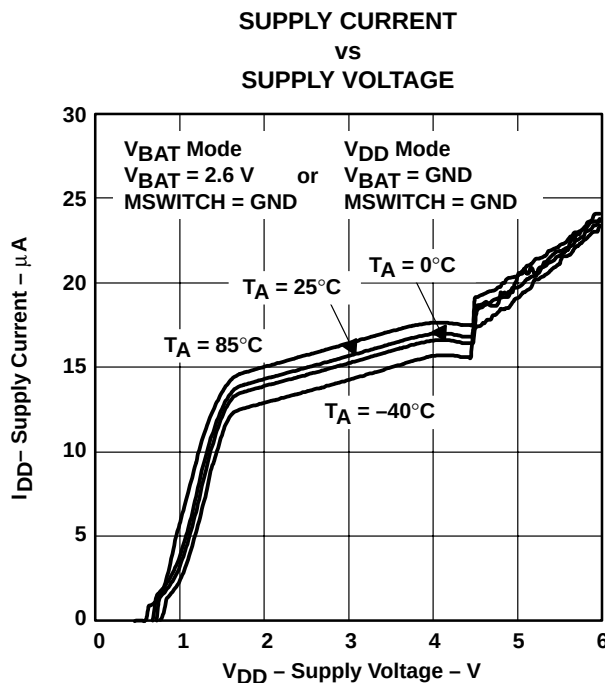


Figure 9

TPS3610U18, TPS3610T50
BATTERY-BACKUP SUPERVISORS FOR RAM RETENTION

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TYPICAL CHARACTERISTICS

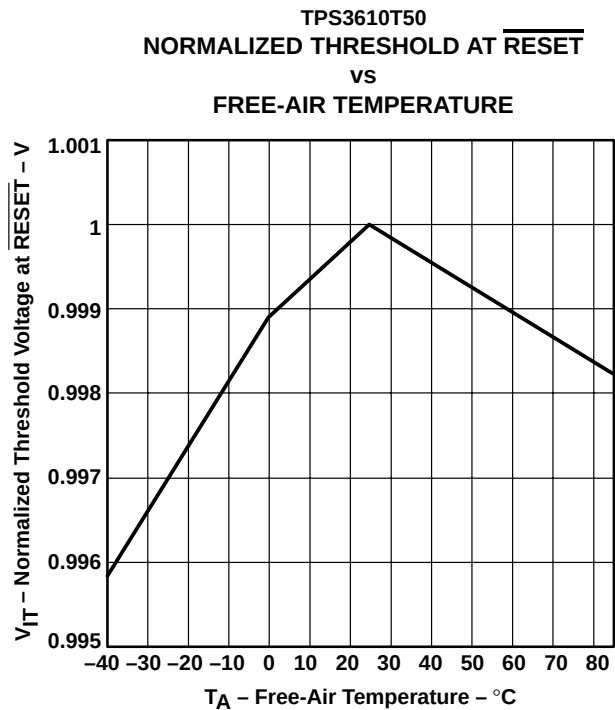


Figure 10

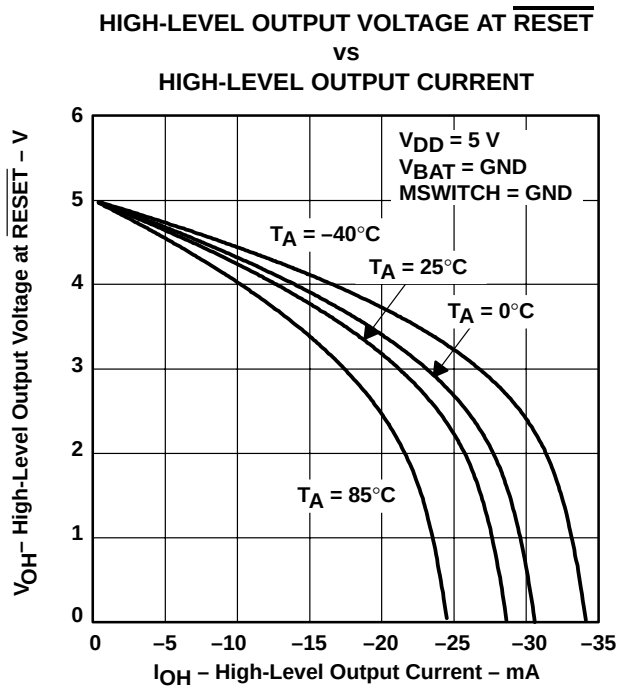


Figure 11

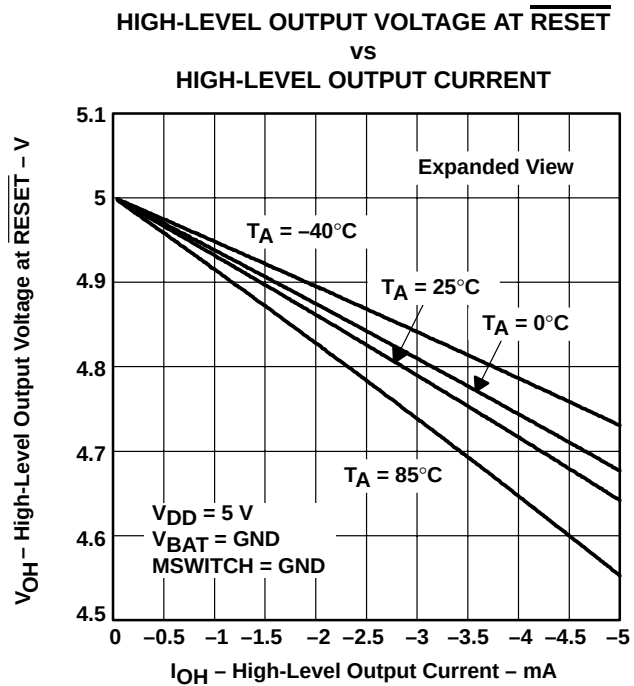


Figure 12

TYPICAL CHARACTERISTICS

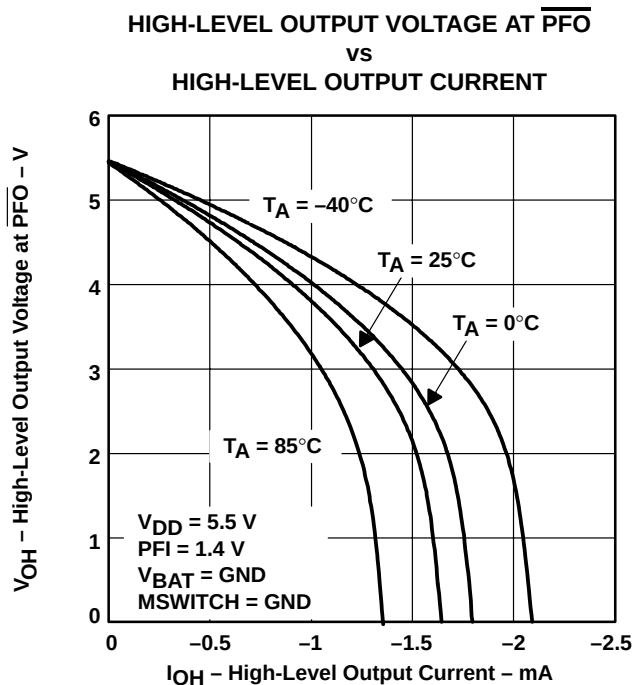


Figure 13

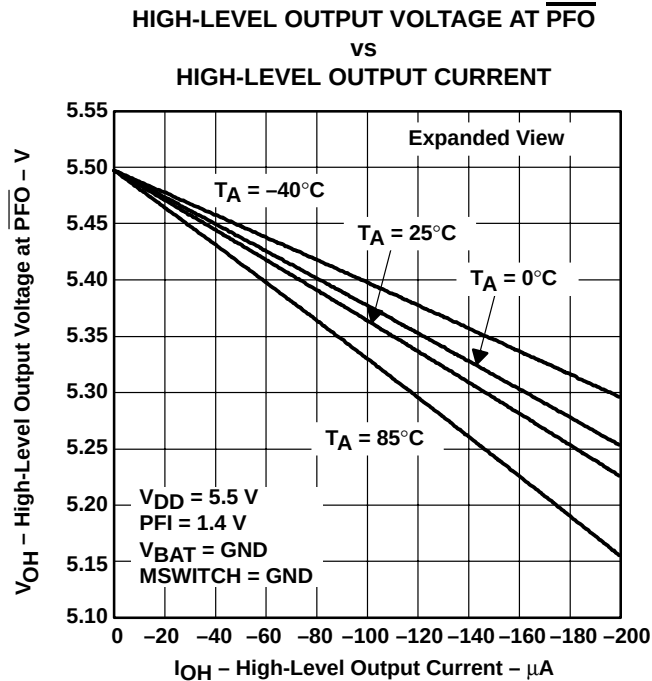


Figure 14

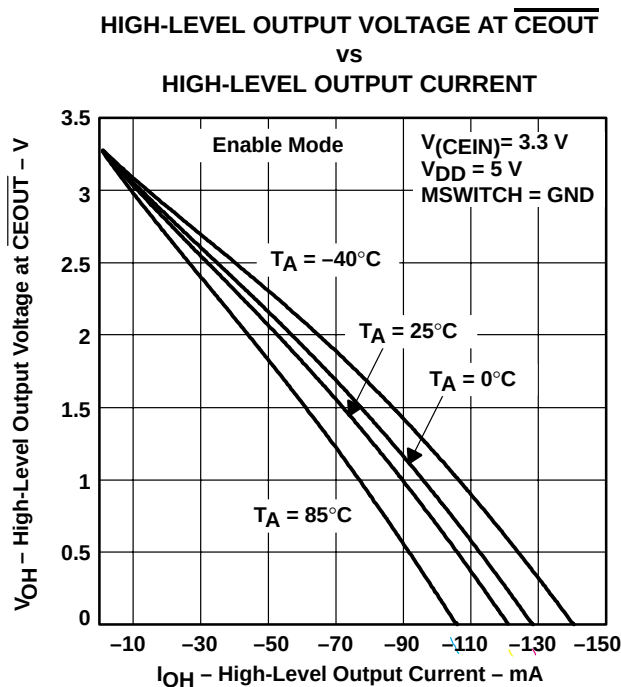


Figure 15

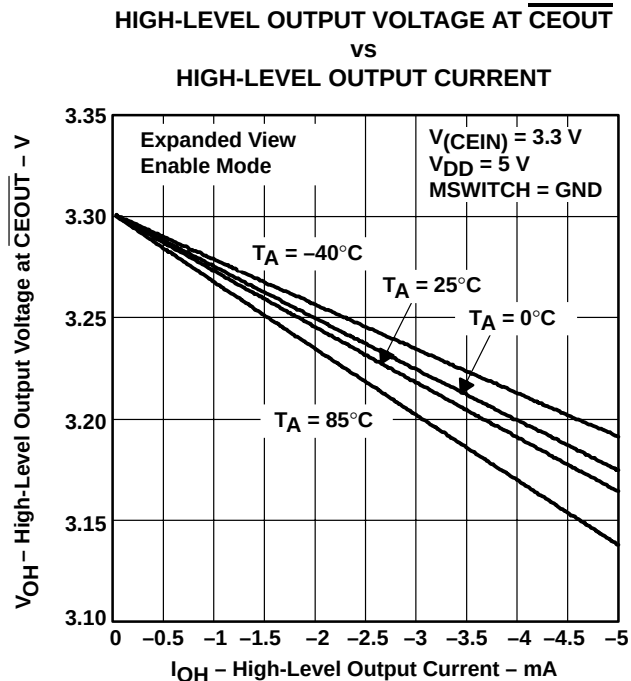
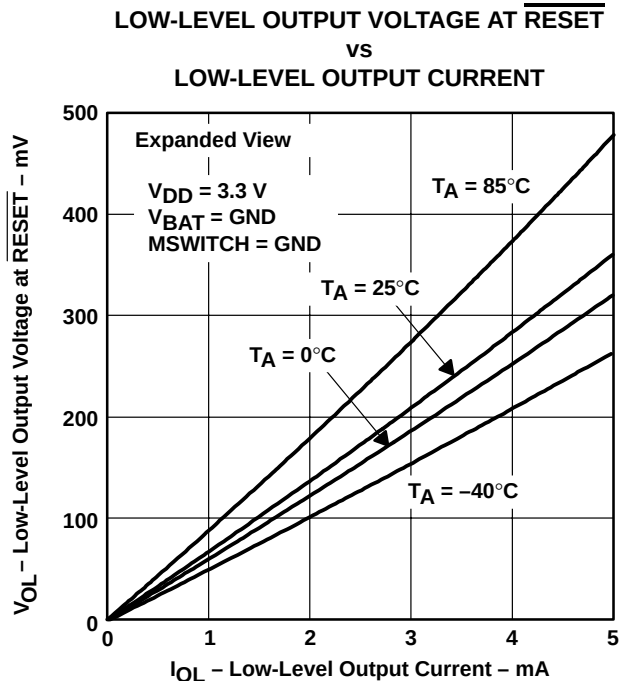
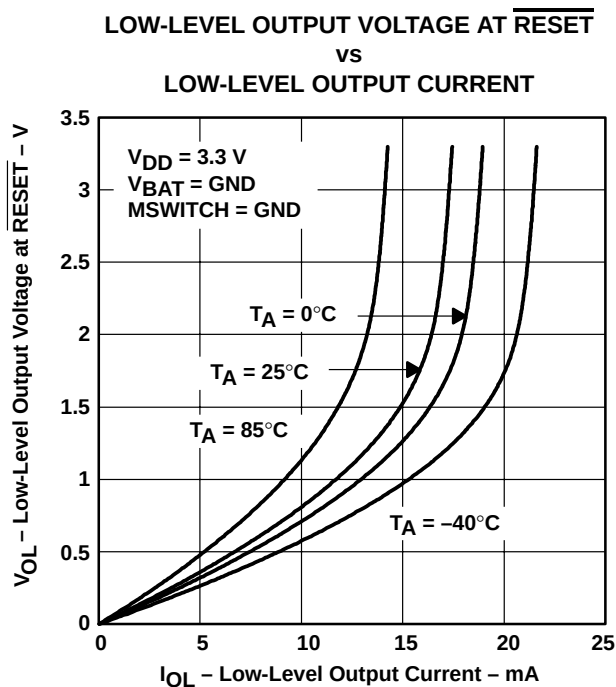
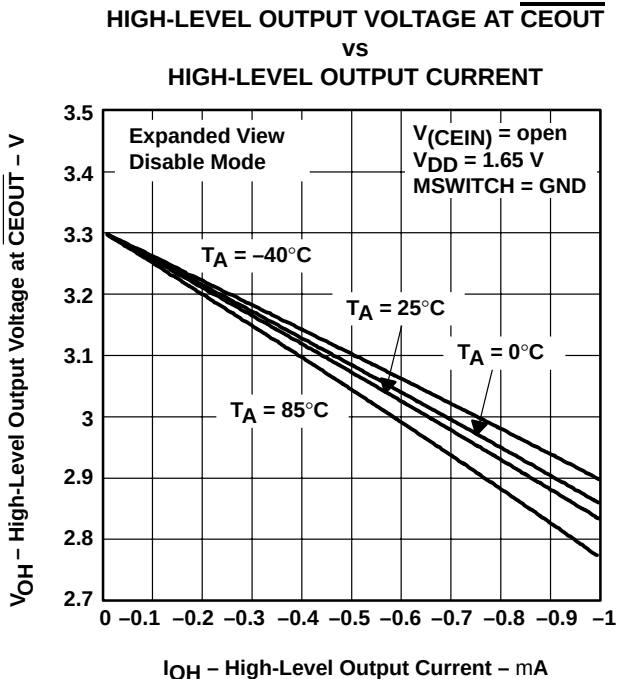
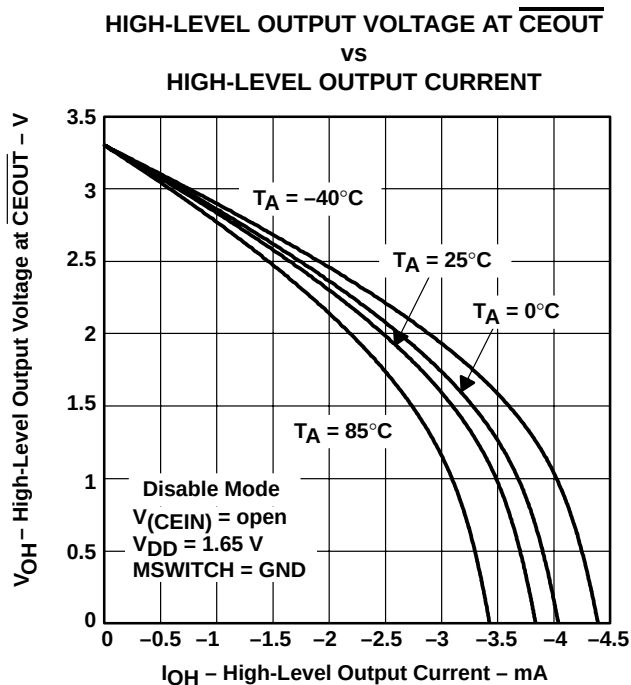


Figure 16

TPS3610U18, TPS3610T50 BATTERY-BACKUP SUPERVISORS FOR RAM RETENTION

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TYPICAL CHARACTERISTICS



TYPICAL CHARACTERISTICS

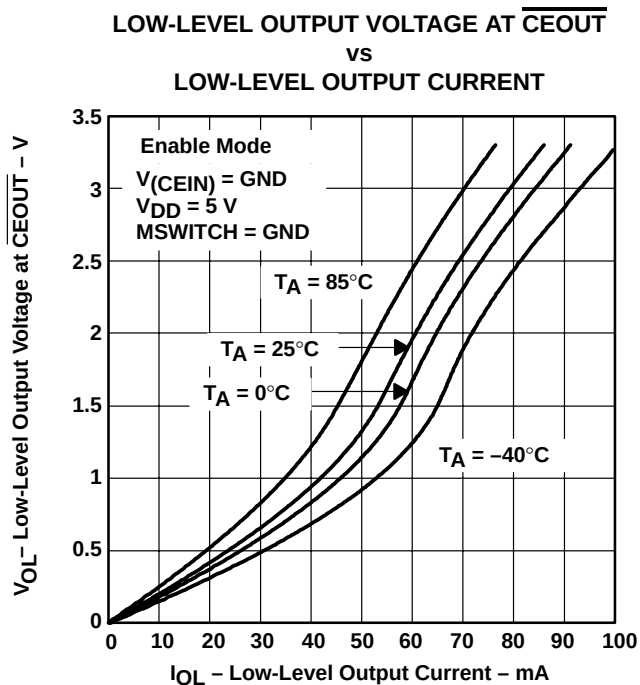


Figure 21

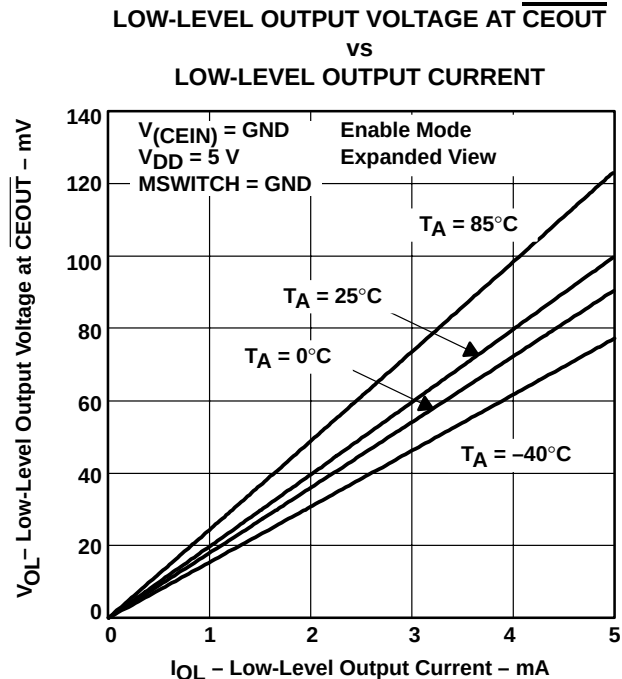


Figure 22

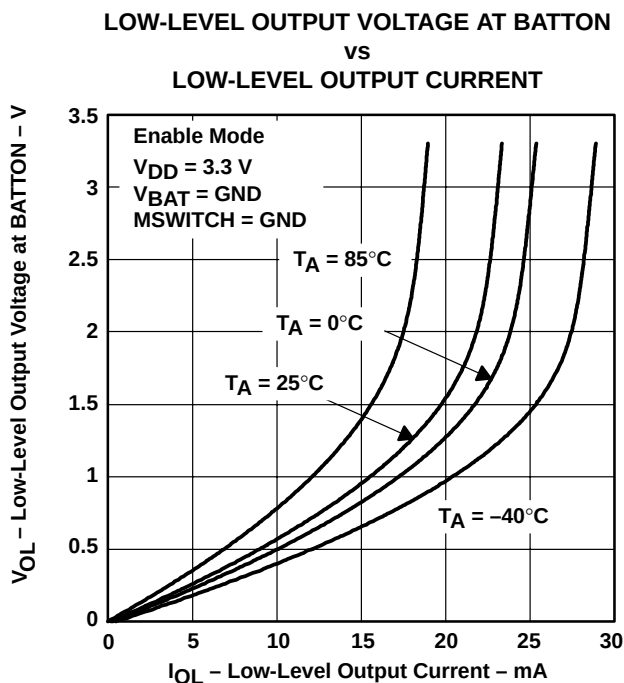


Figure 23

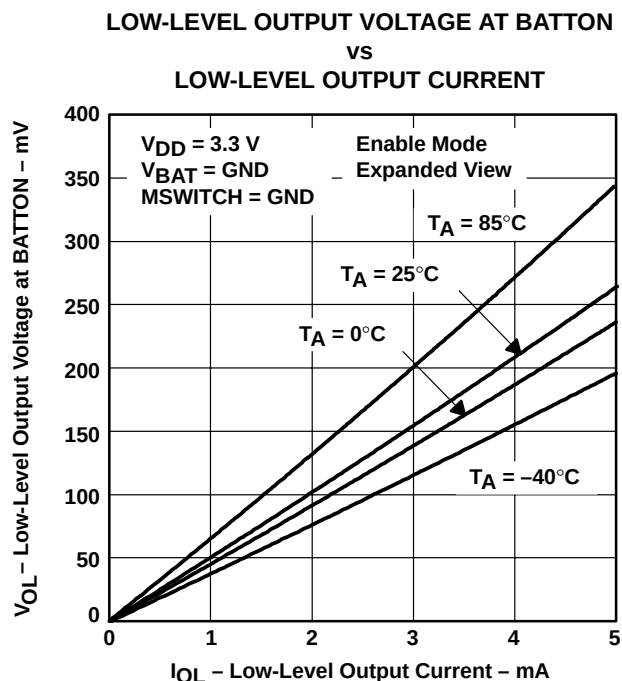


Figure 24

TPS3610U18, TPS3610T50 BATTERY-BACKUP SUPERVISORS FOR RAM RETENTION

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TYPICAL CHARACTERISTICS

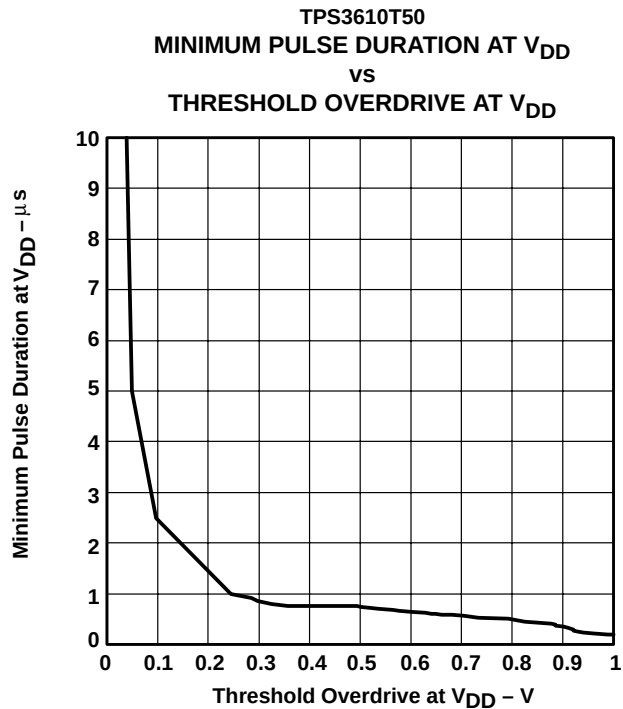


Figure 25

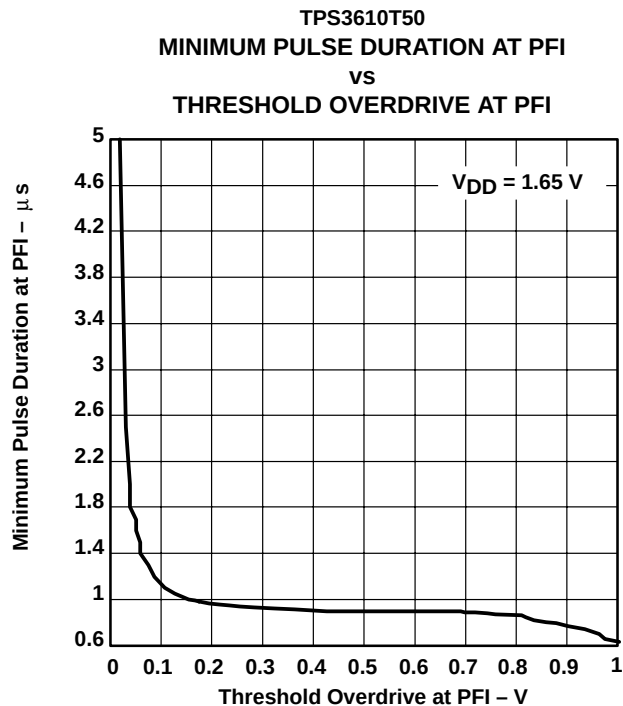


Figure 26

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package Pins	Package qty Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
TPS3610T50PW	Obsolete	Production	TSSOP (PW) 14	-	-	Call TI	Call TI	-40 to 85	3610T50
TPS3610T50PWR	Active	Production	TSSOP (PW) 14	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	3610T50
TPS3610T50PWR.A	Active	Production	TSSOP (PW) 14	2000 LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	3610T50
TPS3610U18PW	Active	Production	TSSOP (PW) 14	90 TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	3610U18
TPS3610U18PW.A	Active	Production	TSSOP (PW) 14	90 TUBE	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 85	3610U18

⁽¹⁾ **Status:** For more details on status, see our [product life cycle](#).

⁽²⁾ **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

⁽³⁾ **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

⁽⁴⁾ **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

⁽⁵⁾ **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

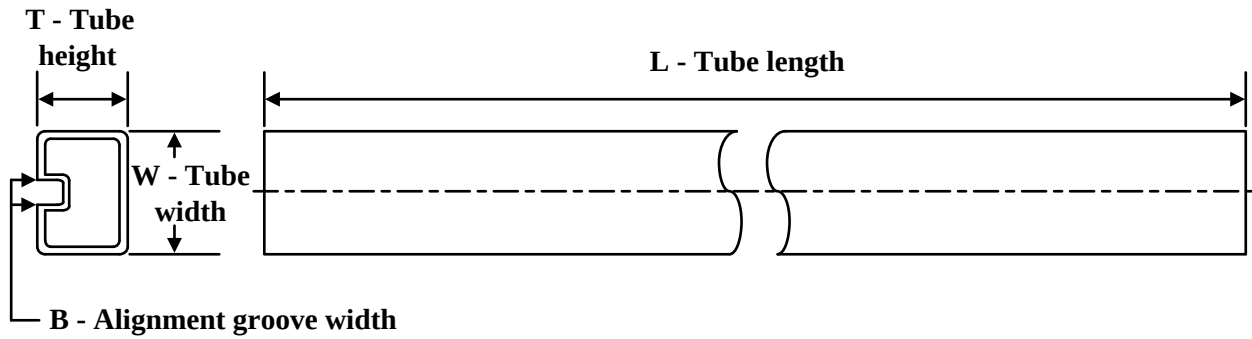
⁽⁶⁾ **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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TUBE



*All dimensions are nominal

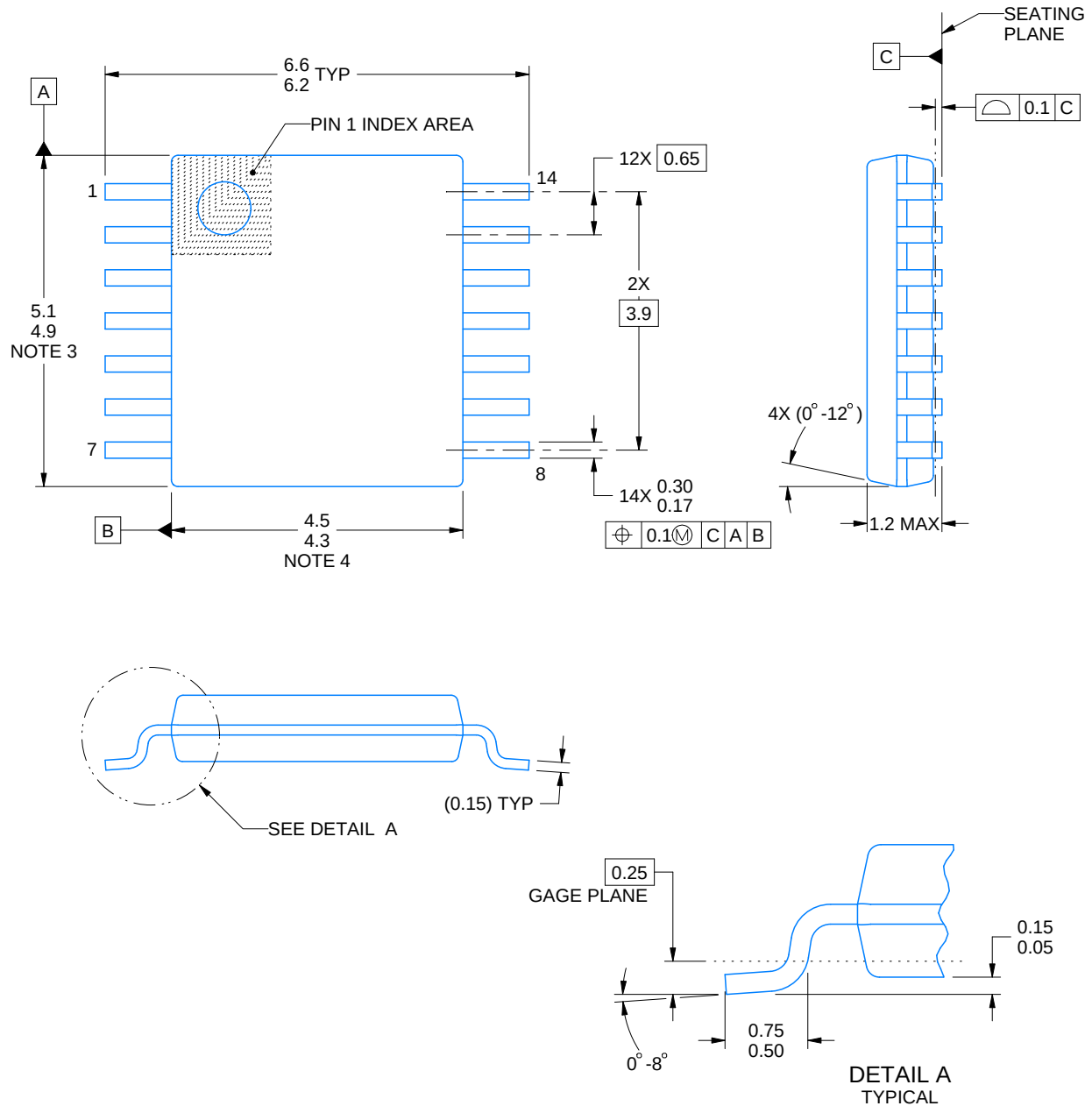
Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (μm)	B (mm)
TPS3610T50PWR	PW	TSSOP	14	2000	530	10.2	3600	3.5
TPS3610T50PWR.A	PW	TSSOP	14	2000	530	10.2	3600	3.5
TPS3610U18PW	PW	TSSOP	14	90	530	10.2	3600	3.5
TPS3610U18PW.A	PW	TSSOP	14	90	530	10.2	3600	3.5

PW0014A

PACKAGE OUTLINE

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



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NOTES:

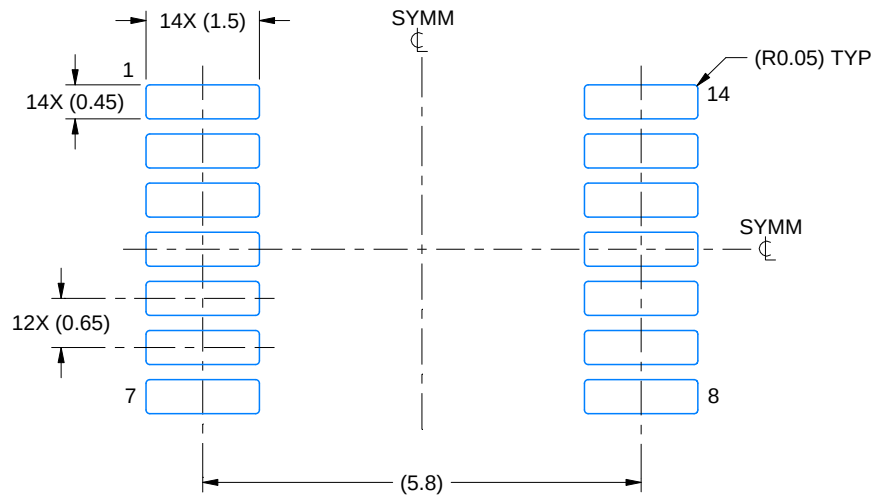
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-153.

EXAMPLE BOARD LAYOUT

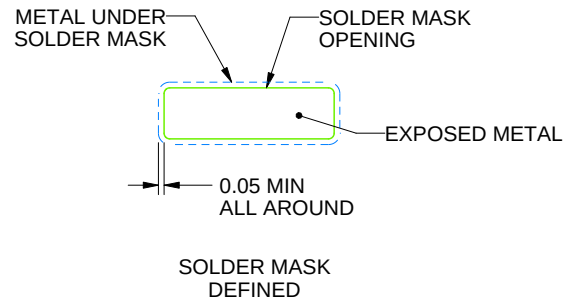
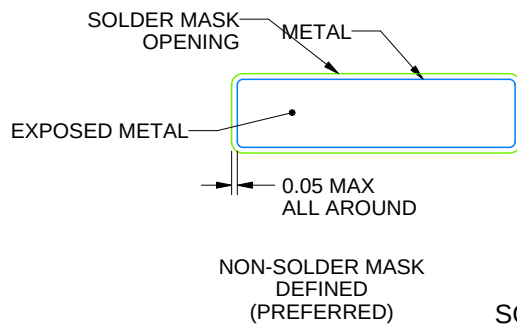
PW0014A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 10X



SOLDER MASK DETAILS

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NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

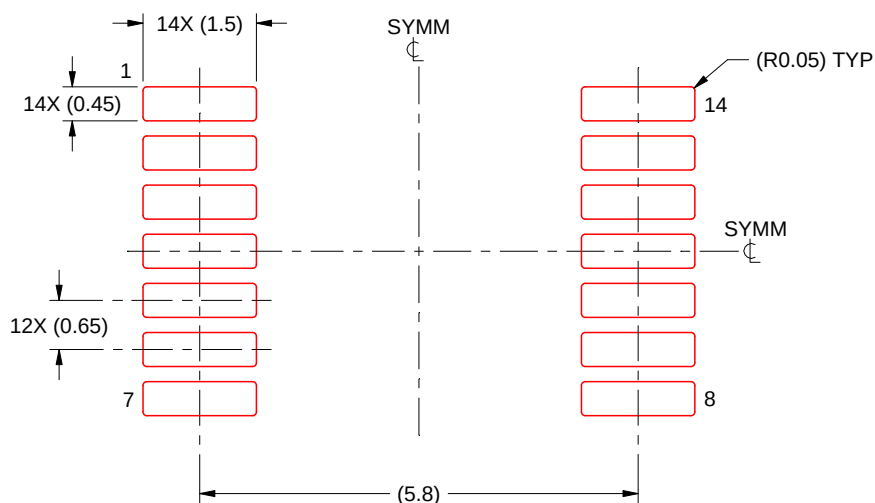
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

PW0014A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



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

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NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

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