# SIMPLE SWITCHER®Power Converter 150 kHz 2A Step-Down Voltage Regulator

## General Description

The LM2592HV series of regulators are monolithic integrated circuits that provide all the active functions for a step-down (buck) switching regulator, capable of driving a 2A load with excellent line and load regulation. These devices are available in fixed output voltages of 3.3V, 5V, and an adjustable output version.

This series of switching regulators is similar to the LM2593HV, but without some of the supervisory and performance features of the latter.

Requiring a minimum number of external components, these regulators are simple to use and include internal frequency compensation†, improved line and load specifications and a fixed-frequency oscillator.

The LM2592HV operates at a switching frequency of 150 kHz thus allowing smaller sized filter components than what would be needed with lower frequency switching regulators. Available in a standard 5-lead TO-220 package with several different lead bend options, and a 5-lead TO-263 Surface mount package.

Other features include a guaranteed ±4% tolerance on output voltage under all conditions of input voltage and output load conditions, and ±15% on the oscillator frequency. External shutdown is included, featuring typically 90 µA standby current. Self protection features include a two stage current limit for the output switch and an over temperature shutdown for complete protection under fault conditions.

## Features

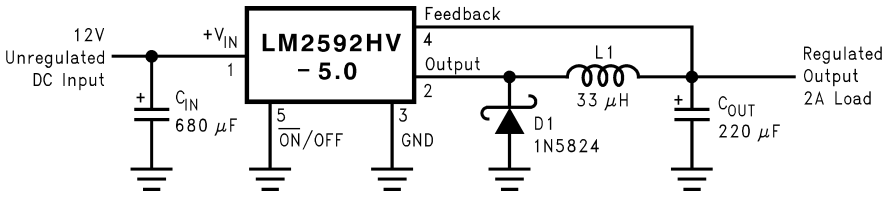
- 3.3V, 5V, and adjustable output versions
- Adjustable version output voltage range, 1.2V to 57V ±4% max over line and load conditions
- Guaranteed 2A output load current
- Available in 5-pin TO-220 and TO-263 (surface mount) Package
- Input voltage range up to 60V
- 150 kHz fixed frequency internal oscillator
- On/Off control
- Low power standby mode, $I_Q$ typically 90 µA
- High Efficiency
- Thermal shutdown and current limit protection

## Applications

- Simple high-efficiency step-down (buck) regulator
- Efficient pre-regulator for linear regulators
- On-card switching regulators
- Positive to Negative converter

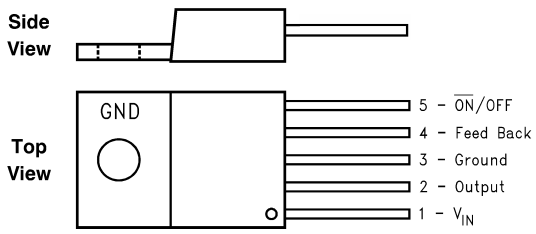
**Note:** † Patent Number 5,382,918.

## Typical Application (Fixed Output Voltage Versions)



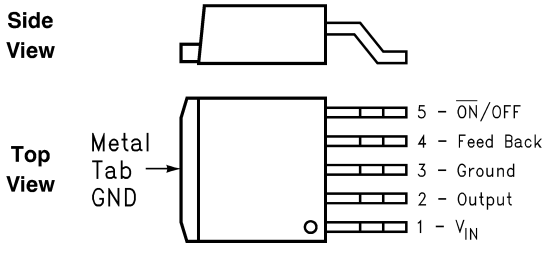

## Connection Diagrams

**Bent and Staggered Leads, Through Hole Package**
**5-Lead TO-220 (T)**




**Order Number LM2592HVT-3.3, LM2592HVT-5.0, or LM2592HVT-ADJ**

**Surface Mount Package**
**5-Lead TO-263 (S)**




**Order Number LM2592HVS-3.3, LM2592HVS-5.0, or LM2592HVS-ADJ**

## Absolute Maximum Ratings (Note 1)

**If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.**

| | |
|---|---|
| Maximum Supply Voltage ($V_{IN}$) | 63V |
| $\overline{ON}$/OFF Pin Voltage | −0.3 ≤ V ≤ +25V |
| Feedback Pin Voltage | −0.3 ≤ V ≤ +25V |
| Output Voltage to Ground (Steady State) | −1V |
| Power Dissipation | Internally limited |
| Storage Temperature Range | −65˚C to +150˚C |
| ESD Susceptibility | |
| Human Body Model (Note 2) | 2 kV |
| Lead Temperature | |
| S Package | |
| Vapor Phase (60 sec.) | +215˚C |
| Infrared (10 sec.) | +245˚C |
| T Package (Soldering, 10 sec.) | +260˚C |
| Maximum Junction Temperature | +150˚C |

## Operating Conditions

| | |
|---|---|
| Temperature Range | −40˚C ≤ $T_J$ ≤ +125˚C |
| Supply Voltage | 4.5V to 60V |

## LM2592HV-3.3 Electrical Characteristics

Specifications with standard type face are for $T_J$ = 25˚C, and those with **boldface type** apply over **full Operating Temperature Range.**

| Symbol | Parameter | Conditions | LM2592HV-3.3 | | Units (Limits) |
|---|---|---|---|---|---|
| | | | Typ (Note 3) | Limit (Note 4) | |
| **SYSTEM PARAMETERS** (Note 5) Test Circuit *Figure 1* | | | | | |
| $V_{OUT}$ | Output Voltage | 4.75V ≤ $V_{IN}$ ≤ 60V, 0.2A ≤ $I_{LOAD}$ ≤ 2A | 3.3 | <br>3.168/**3.135**<br>3.432/**3.465** | V<br>V(min)<br>V(max) |
| η | Efficiency | $V_{IN}$ = 12V, $I_{LOAD}$ = 2A | 76 | | |

## LM2592HV-5.0 Electrical Characteristics

Specifications with standard type face are for $T_J$ = 25˚C, and those with **boldface type** apply over **full Operating Temperature Range.**

| Symbol | Parameter | Conditions | LM2592HV-5.0 | | Units (Limits) |
|---|---|---|---|---|---|
| | | | Typ (Note 3) | Limit (Note 4) | |
| **SYSTEM PARAMETERS** (Note 5) Test Circuit *Figure 1* | | | | | |
| $V_{OUT}$ | Output Voltage | 7V ≤ $V_{IN}$ ≤ 60V, 0.2A ≤ $I_{LOAD}$ ≤ 2A | 5 | <br>4.800/**4.750**<br>5.200/**5.250** | V<br>V(min)<br>V(max) |
| η | Efficiency | $V_{IN}$ = 12V, $I_{LOAD}$ = 2A | 81 | | % |

## LM2592HV-ADJ Electrical Characteristics

Specifications with standard type face are for $T_J$ = 25˚C, and those with **boldface type** apply over **full Operating Temperature Range.**

| Symbol | Parameter | Conditions | LM2592HV-ADJ | | Units (Limits) |
|---|---|---|---|---|---|
| | | | Typ (Note 3) | Limit (Note 4) | |
| **SYSTEM PARAMETERS** (Note 5) Test Circuit *Figure 1* | | | | | |
| $V_{FB}$ | Feedback Voltage | 4.5V ≤ $V_{IN}$ ≤ 60V, 0.2A ≤ $I_{LOAD}$ ≤ 2A<br>$V_{OUT}$ programmed for 3V. Circuit of *Figure 1.* | 1.230 | <br>1.193/**1.180**<br>1.267/**1.280** | V<br>V(min)<br>V(max) |
| η | Efficiency | $V_{IN}$ = 12V, $V_{OUT}$ = 3V, $I_{LOAD}$ = 2A | 75 | | % |

## All Output Voltage Versions
## Electrical Characteristics

Specifications with standard type face are for $T_J$ = 25˚C, and those with **boldface type** apply over **full Operating Temperature Range**. Unless otherwise specified, $V_{IN}$ = 12V for the 3.3V, 5V, and Adjustable version. $I_{LOAD}$ = 500 mA

| Symbol | Parameter | Conditions | LM2592HV-XX | | Units (Limits) |
|---|---|---|---|---|---|
| | | | Typ (Note 3) | Limit (Note 4) | |
| **DEVICE PARAMETERS** | | | | | |
| $I_b$ | Feedback Bias Current | Adjustable Version Only, $V_{FB}$ = 1.3V | 10 | 50/**100** | nA<br>nA (max) |
| $f_O$ | Oscillator Frequency | (Note 6) | 150 | 127/**110**<br>173/**173** | kHz<br>kHz(min)<br>kHz(max) |
| $V_{SAT}$ | Saturation Voltage | $I_{OUT}$ = 2A (Note 7) (Note 8) | 1.10 | 1.3/**1.4** | V<br>V(max) |
| DC | Max Duty Cycle (ON)<br>Min Duty Cycle (OFF) | (Note 8)<br>(Note 9) | 100<br>0 | | % |
| $I_{CLIM}$ | Switch current Limit | Peak Current, (Note 7) (Note 8) | 3.0 | 2.4/**2.3**<br>3.7/**4.0** | A<br>A(min)<br>A(max) |
| $I_L$ | Output Leakage Current | (Note 7) (Note 9) (Note 10) Output = 0V<br>Output = −1V | <br>5 | 50<br><br>30 | µA(max)<br>mA<br>mA(max) |
| $I_Q$ | Operating Quiescent Current | $\overline{SD}$ /SS Pin Open (Note 9) | 5 | 10 | mA<br>mA(max) |
| $I_{STBY}$ | Standby Quiescent Current | $\overline{SD}$ /SS pin = 0V (Note 10) | 90 | 200/**250** | µA<br>µA(max) |
| $\theta_{JC}$<br>$\theta_{JA}$<br>$\theta_{JA}$<br>$\theta_{JA}$<br>$\theta_{JA}$ | Thermal Resistance | TO220 or TO263 Package, Junction to Case<br>TO220 Package, Juncton to Ambient (Note 11)<br>TO263 Package, Juncton to Ambient (Note 12)<br>TO263 Package, Juncton to Ambient (Note 13)<br>TO263 Package, Juncton to Ambient (Note 14) | 2<br>50<br>50<br>30<br>20 | | ˚C/W<br>˚C/W<br>˚C/W<br>˚C/W<br>˚C/W |
| **ON/OFF CONTROL** Test Circuit *Figure 1* | | | | | |
| <br>$V_{IH}$<br>$V_{IL}$ | $\overline{ON}$ /OFF Pin Logic Input<br>Threshold Voltage | <br>Low (Regulator ON)<br>High (Regulator OFF) | 1.3 | <br>**0.6**<br>**2.0** | V<br>V(max)<br>V(min) |
| $I_H$ | $\overline{ON}$ /OFF Pin Input Current | $V_{LOGIC}$ = 2.5V (Regulator OFF) | 5 | 15 | µA<br>µA(max) |
| $I_L$ | | $V_{LOGIC}$ = 0.5V (Regulator ON) | 0.02 | 5 | µA<br>µA(max) |

## All Output Voltage Versions
## Electrical Characteristics (Continued)

**Note 1:** Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but do not guarantee specific performance limits. For guaranteed specifications and test conditions, see the Electrical Characteristics.

**Note 2:** The human body model is a 100 pF capacitor discharged through a 1.5k resistor into each pin.

**Note 3:** Typical numbers are at 25˚C and represent the most likely norm.

**Note 4:** All limits guaranteed at room temperature (standard type face) and at **temperature extremes (bold type face)**. All room temperature limits are 100% production tested. All limits at **temperature extremes** are guaranteed via correlation using standard Statistical Quality Control (SQC) methods. All limits are used to calculate Average Outgoing Quality Level (AOQL).

**Note 5:** External components such as the catch diode, inductor, input and output capacitors can affect switching regulator system performance. When the LM2592HV is used as shown in the *Figure 1* test circuit, system performance will be as shown in system parameters section of Electrical Characteristics.

**Note 6:** The switching frequency is reduced when the second stage current limit is activated. The amount of reduction is determined by the severity of current overload.

**Note 7:** No diode, inductor or capacitor connected to output pin.

**Note 8:** Feedback pin removed from output and connected to 0V to force the output transistor switch ON.

**Note 9:** Feedback pin removed from output and connected to 12V for the 3.3V, 5V, and the ADJ. version to force the output transistor switch OFF.

**Note 10:** $V_{IN}$ = 60V.

**Note 11:** Junction to ambient thermal resistance (no external heat sink) for the package mounted TO-220 package mounted vertically, with the leads soldered to a printed circuit board with (1 oz.) copper area of approximately 1 $in^2$.

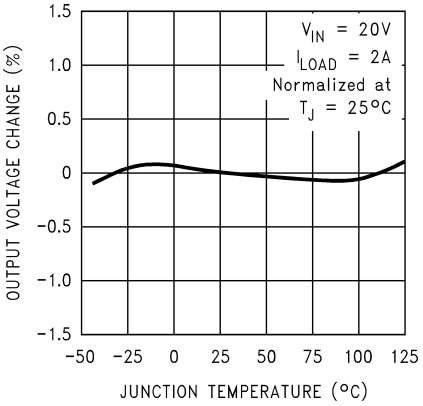
**Note 12:** Junction to ambient thermal resistance with the TO-263 package tab soldered to a single sided printed circuit board with 0.5 $in^2$ of (1 oz.) copper area.

**Note 13:** Junction to ambient thermal resistance with the TO-263 package tab soldered to a single sided printed circuit board with 2.5 $in^2$ of (1 oz.) copper area.

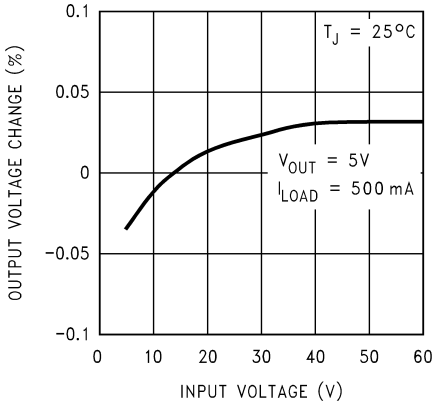
**Note 14:** Junction to ambient thermal resistance with the TO-263 package tab soldered to a double sided printed circuit board with 3 $in^2$ of (1 oz.) copper area on the LM2592HVS side of the board, and approximately 16 $in^2$ of copper on the other side of the p-c board. See application hints in this data sheet and the thermal model in **Switchers Made Simple** available at http://power.national.com.

## Typical Performance Characteristics (Circuit of *Figure 1*)

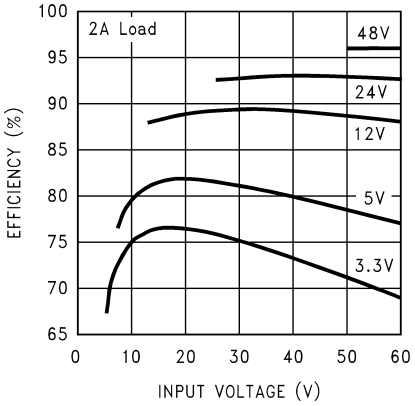
**Normalized Output Voltage**



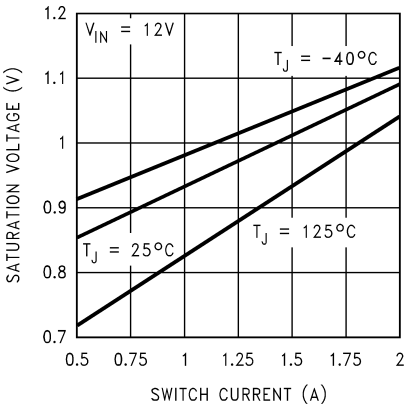

**Line Regulation**



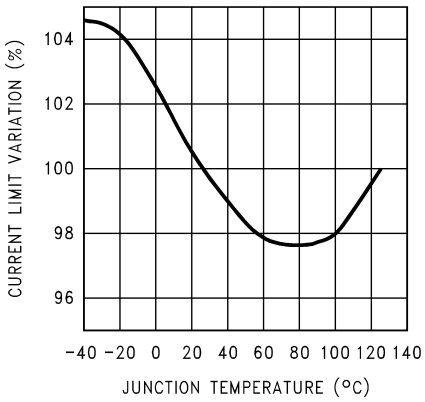

**Efficiency**



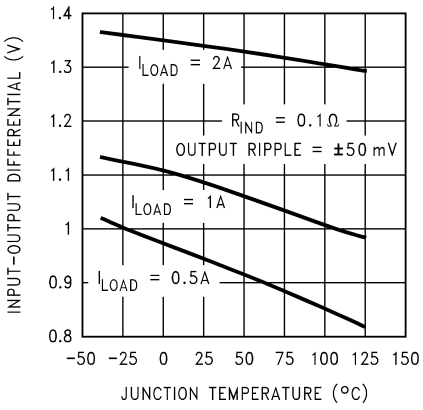

**Switch Saturation Voltage**



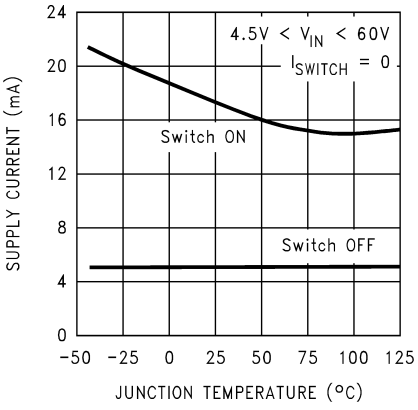

**Switch Current Limit**



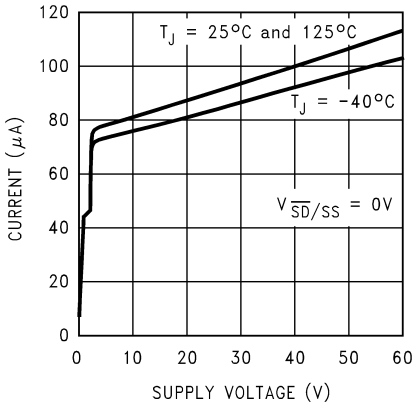

**Dropout Voltage**



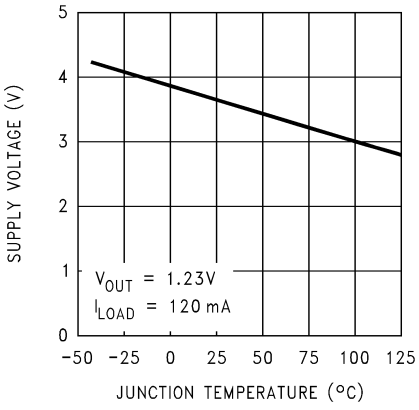

**Operating Quiescent Current**




**Shutdown Quiescent Current**

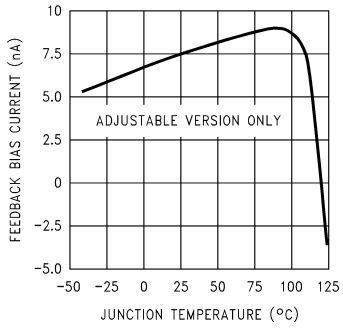



**Minimum Operating Supply Voltage**

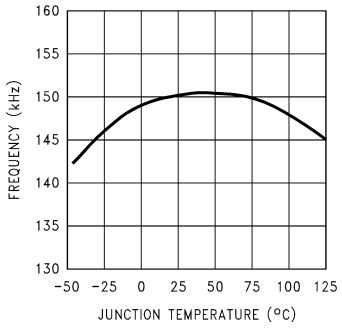


## Typical Performance Characteristics (Circuit of *Figure 1*) (Continued)

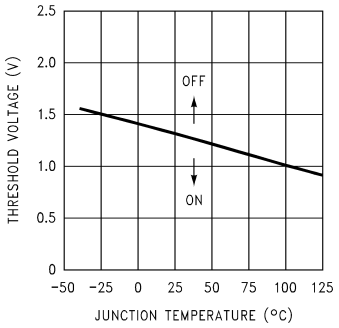
**Feedback Pin Bias Current**



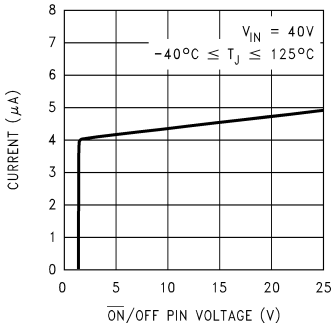

**Switching Frequency**



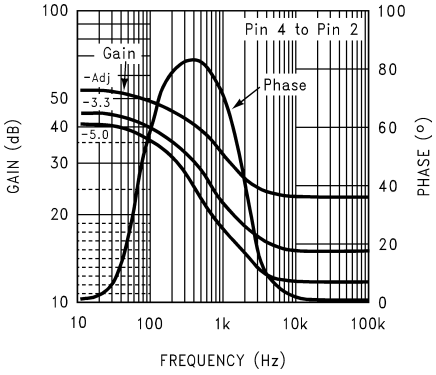

**$\overline{ON}$/OFF Threshold Voltage**



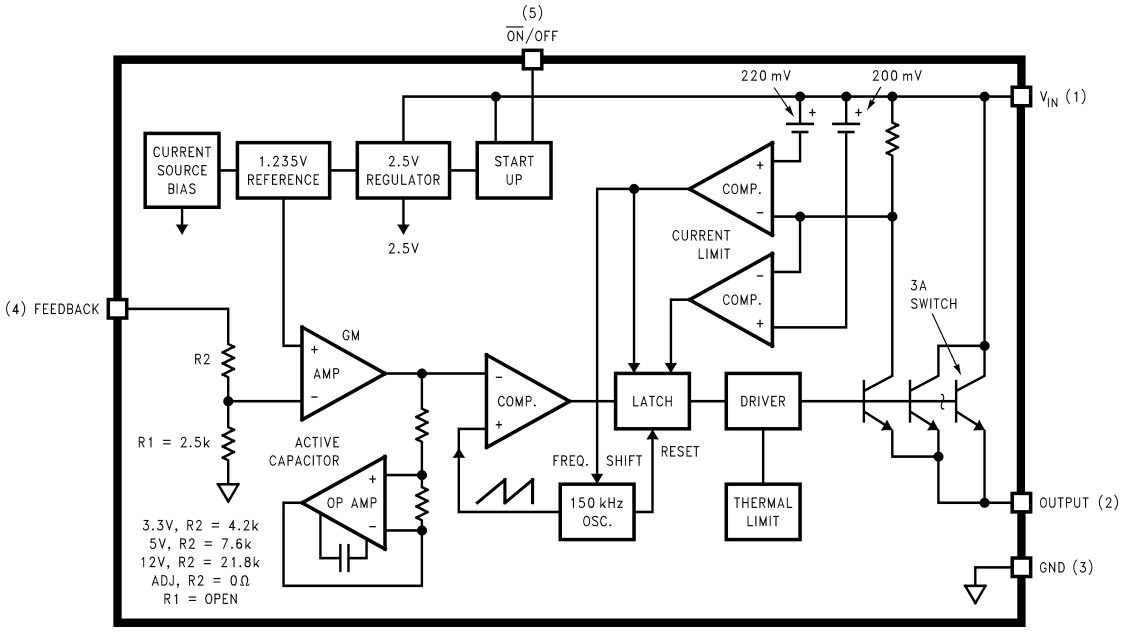

**$\overline{ON}$/OFF Pin Current (Sinking)**




**Internal Gain-Phase Characteristics**



## Block Diagram




## PIN FUNCTIONS

**+$V_{IN}$** (Pin 1)—This is the positive input supply for the IC switching regulator. A suitable input bypass capacitor must be present at this pin to minimize voltage transients and to supply the switching currents needed by the regulator.

**Output** (Pin 2)—Internal switch. The voltage at this pin switches between approximately (+$V_{IN}$ − $V_{SAT}$) and approximately −0.5V, with a duty cycle of $V_{OUT}/V_{IN}$.

**Ground** (Pin 3)—Circuit ground.

**Feedback** (Pin 4)—Senses the regulated output voltage to complete the feedback loop. This pin is directly connected to the Output for the fixed voltage versions, but is set to 1.23V by means of a resistive divider from the output for the Adjustable version. If a feedforward capacitor is used (Adjustable version), then a negative voltage spike is generated on this pin whenever the output is shorted. This happens because the feedforward capacitor cannot discharge fast enough, and since one end of it is dragged to Ground, the other end goes momentarily negative. To prevent the energy rating of this pin from being exceeded, a small-signal Schottky diode to Ground is recommended for DC input voltages above 40V whenever a feedforward capacitor is present (See *Figure 1*). Feedforward capacitor values larger than 0.1 µF are not recommended for the same reason, whatever be the DC input voltage.

**$\overline{\text{ON}}$ /OFF** (Pin 5)—The regulator is in shutdown mode, drawing about 90 µA, when this pin is driven to a high level (≥ 2.0V), and is in normal operation when this Pin is left floating or driven to a low level (≤ 0.6V). The typical value of the threshold is 1.3V and the voltage on this pin must not exceed 25V.

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