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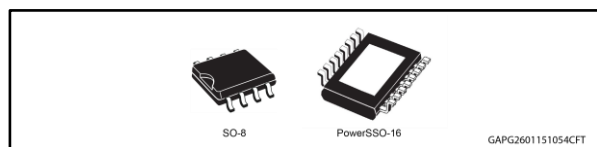
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## High-side driver with MultiSense analog feedback for automotive applications

Datasheet - production data



- Loss of ground and loss of  $V_{CC}$
- Reverse battery with external components
- Electrostatic discharge protection

### Features

Max transient supply voltage	$V_{CC}$	40 V
Operating voltage range	$V_{CC}$	4 to 28 V
Typ. on-state resistance (per Ch)	$R_{ON}$	140 m $\Omega$
Current limitation (typ)	$I_{LIMH}$	12 A
Standby current (max)	$I_{STBY}$	0.5 $\mu$ A

- AEC-Q100 qualified
- General
  - Single channel smart high-side driver with MultiSense analog feedback
  - Very low standby current
  - Compatible with 3 V and 5 V CMOS outputs
- MultiSense diagnostic functions
  - Multiplexed analog feedback of: load current with high precision proportional current mirror,  $V_{CC}$  supply voltage and  $T_{CHIP}$  device temperature
  - Overload and short to ground (power limitation) indication
  - Thermal shutdown indication
  - OFF-state open-load detection
  - Output short to  $V_{CC}$  detection
  - Sense enable/disable
- Protections
  - Undervoltage shutdown
  - Overvoltage clamp
  - Load current limitation
  - Self limiting of fast thermal transients
  - Configurable latch-off on overtemperature or power limitation with dedicated fault reset pin



### Applications

- All types of automotive resistive, inductive and capacitive loads
- Specially intended for automotive signal lamps (up to R10W or LED Rear Combinations)

### Description

The devices are single channel high-side drivers manufactured using ST proprietary VIPower<sup>®</sup> M0-7 technology and housed in PowerSSO-16 and SO-8 packages. The devices are designed to drive 12 V automotive grounded loads through a 3 V and 5 V CMOS-compatible interface, and to provide protection and diagnostics.

The devices integrate advanced protective functions such as load current limitation, overload active management by power limitation and overtemperature shutdown with configurable latch-off.

A  $\overline{\text{FaultRST}}$  pin unlatches the output in case of fault or disables the latch-off functionality.

A dedicated multifunction multiplexed analog output pin delivers sophisticated diagnostic functions including high precision proportional load current sense, supply voltage feedback and chip temperature sense, in addition to the detection of overload and short circuit to ground, short to  $V_{CC}$  and OFF-state open-load.

A sense enable pin allows OFF-state diagnosis to be disabled during the module low-power mode as well as external sense resistor sharing among similar devices.

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# 1 Block diagram and pin description

Figure 1: Block diagram

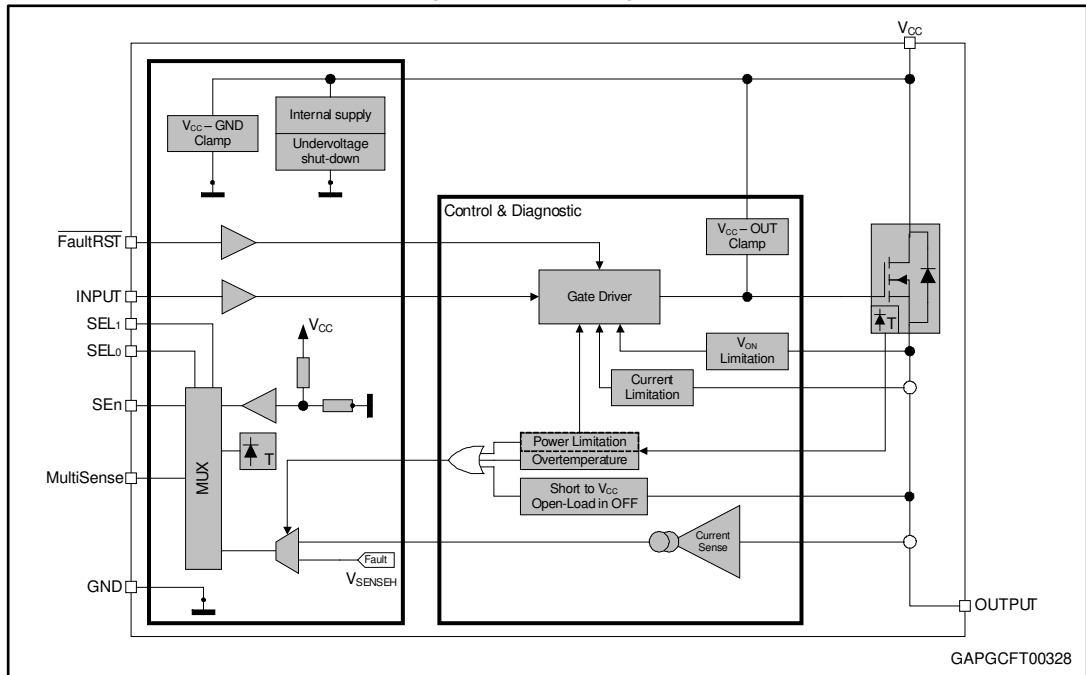


Table 1: Pin functions

Name	Function
V <sub>CC</sub>	Battery connection.
OUTPUT	Power outputs.
GND	Ground connection. Must be reverse battery protected by an external diode / resistor network.
INPUT	Voltage controlled input pin with hysteresis, compatible with 3 V and 5 V CMOS outputs. It controls output switch state.
MultiSense	Multiplexed analog sense output pin; it delivers a current proportional to the selected diagnostic: load current, supply voltage or chip temperature.
SEn	Active high compatible with 3 V and 5 V CMOS outputs pin; it enables the MultiSense diagnostic pin.
SEL <sub>0,1</sub>	Active high compatible with 3 V and 5 V CMOS outputs pin; they address the MultiSense multiplexer.
$\overline{\text{FaultRST}}$	Active low compatible with 3 V and 5 V CMOS outputs pin; it unlatches the output in case of fault; If kept low, sets the outputs in auto-restart mode.



Figure 2: Configuration diagram (top view)

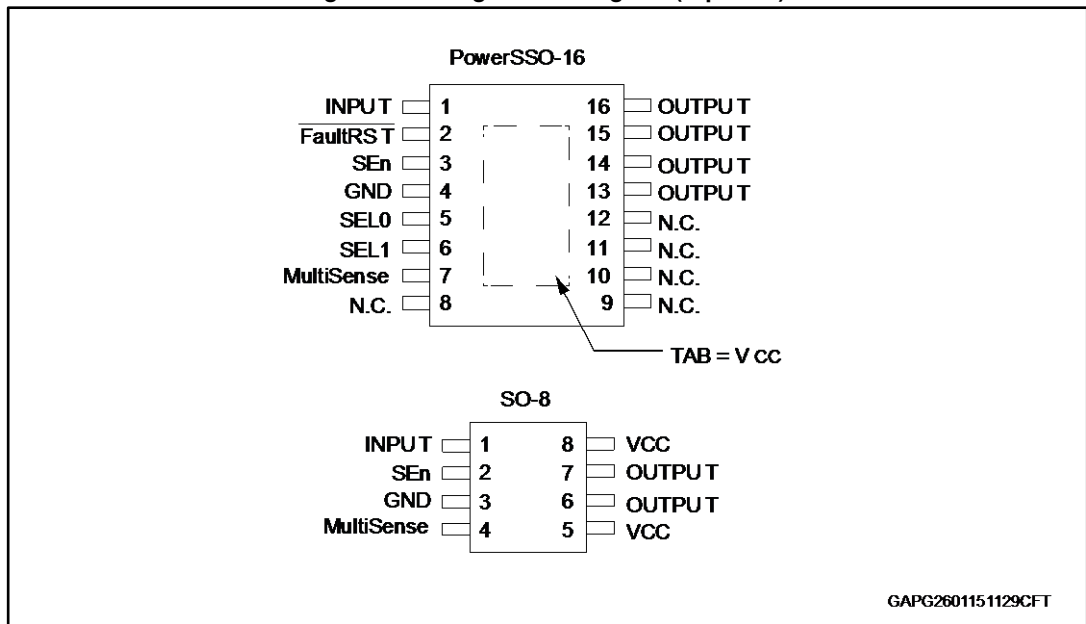


Table 2: Suggested connections for unused and not connected pins

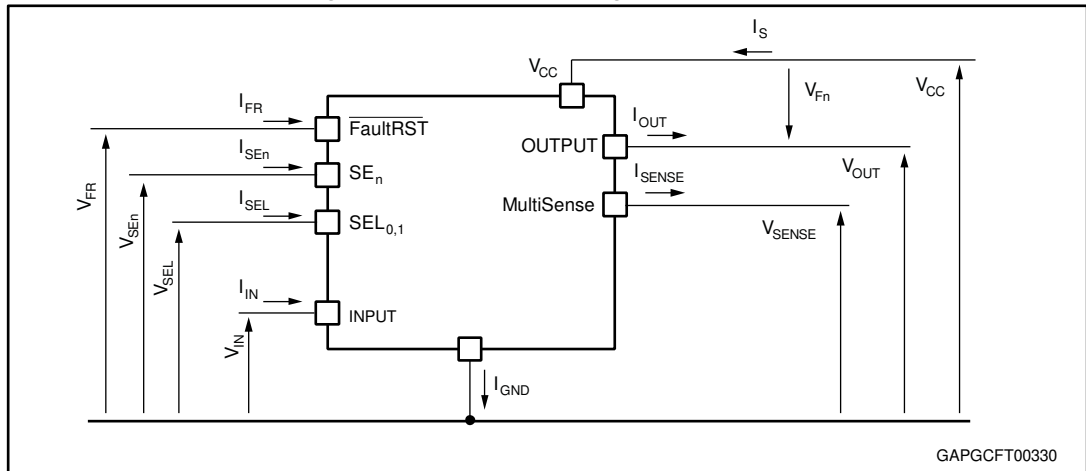
Connection / pin	MultiSense	N.C.	Output	Input	SEn, SELx, FaultRST
Floating	Not allowed	X <sup>(1)</sup>	X	X	X
To ground	Through 1 kΩ resistor	X	Not allowed	Through 15 kΩ resistor	Through 15 kΩ resistor

**Notes:**

<sup>(1)</sup>X: do not care.

## 2 Electrical specification

Figure 3: Current and voltage conventions



$V_F = V_{OUT} - V_{CC}$  during reverse battery condition.

### 2.1 Absolute maximum ratings

Stressing the device above the rating listed in [Table 3: "Absolute maximum ratings"](#) may cause permanent damage to the device. These are stress ratings only and operation of the device at these or any other conditions above those indicated in the operating sections of this specification is not implied. Exposure to the conditions in table below for extended periods may affect device reliability.

Table 3: Absolute maximum ratings

Symbol	Parameter	Value	Unit
$V_{CC}$	DC supply voltage	38	V
$-V_{CC}$	Reverse DC supply voltage	0.3	
$V_{CCPK}$	Maximum transient supply voltage (ISO 16750-2:2010 Test B clamped to 40 V; $R_L = 4 \Omega$ )	40	V
$V_{CCJS}$	Maximum jump start voltage for single pulse short circuit protection	28	V
$-I_{GND}$	DC reverse ground pin current	200	mA
$I_{OUT}$	OUTPUT DC output current	Internally limited	A
$-I_{OUT}$	Reverse DC output current	3	
$I_{IN}$	INPUT DC input current	-1 to 10	mA
$I_{SEn}$	SEn DC input current		
$I_{SEL}$	SEL <sub>0,1</sub> DC input current		
$I_{FR}$	FaultRST DC input current		
$V_{FR}$	FaultRST DC input voltage	7.5	V

Symbol	Parameter	Value	Unit
I <sub>SENSE</sub>	MultiSense pin DC output current ( $V_{GND} = V_{CC}$ and $V_{SENSE} < 0$ V)	10	mA
	MultiSense pin DC output current in reverse ( $V_{CC} < 0$ V)	-20	
E <sub>MAX</sub>	Maximum switching energy (single pulse) ( $T_{DEMAG} = 0.4$ ms; $T_{jstart} = 150$ °C)	10	mJ
V <sub>ESD</sub>	Electrostatic discharge (JEDEC 22A-114F)	4000	V
	• INPUT	2000	V
	• MultiSense	4000	V
	• SEn, SEL <sub>0,1</sub> , FaultRST	4000	V
	• OUTPUT	4000	V
	• V <sub>CC</sub>	4000	V
V <sub>ESD</sub>	Charge device model (CDM-AEC-Q100-011)	750	V
T <sub>j</sub>	Junction operating temperature	-40 to 150	°C
T <sub>stg</sub>	Storage temperature	-55 to 150	

## 2.2 Thermal data

Table 4: Thermal data

Symbol	Parameter	Typ. value		Unit
		SO-8	PowerSSO-16	
R <sub>thj-board</sub>	Thermal resistance junction-board (JEDEC JESD 51-8) <sup>(1)</sup>	31	7.9	°C/W
R <sub>thj-amb</sub>	Thermal resistance junction-ambient (JEDEC JESD 51-2) <sup>(2)</sup>	71	61	
R <sub>thj-amb</sub>	Thermal resistance junction-ambient (JEDEC JESD 51-2) <sup>(1)</sup>	48.5	26.5	

**Notes:**

<sup>(1)</sup>Device mounted on four-layers 2s2p PCB

<sup>(2)</sup>Device mounted on two-layers 2s0p PCB with 2 cm<sup>2</sup> heatsink copper trace

## 2.3 Main electrical characteristics

7 V < V<sub>CC</sub> < 28 V; -40°C < T<sub>j</sub> < 150°C, unless otherwise specified.

All typical values refer to V<sub>CC</sub> = 13 V; T<sub>j</sub> = 25°C, unless otherwise specified.

Table 5: Power section

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V <sub>CC</sub>	Operating supply voltage		4	13	28	V
V <sub>USD</sub>	Undervoltage shutdown				4	V
V <sub>USDReset</sub>	Undervoltage shutdown reset				5	V

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{USDhyst}$	Undervoltage shutdown hysteresis			0.3		V
$R_{ON}$	On-state resistance	$I_{OUT} = 1\text{ A}; T_j = 25^\circ\text{C}$		140		m $\Omega$
		$I_{OUT} = 1\text{ A}; T_j = 150^\circ\text{C}$			280	
		$I_{OUT} = 1\text{ A}; V_{CC} = 4\text{ V}; T_j = 25^\circ\text{C}$			210	
$V_{clamp}$	Clamp voltage	$I_S = 20\text{ mA}; 25^\circ\text{C} < T_j < 150^\circ\text{C}$	41	46	52	V
		$I_S = 20\text{ mA}; T_j = -40^\circ\text{C}$	38			V
$I_{STBY}$	Supply current in standby at $V_{CC} = 13\text{ V}$ (1)	$V_{CC} = 13\text{ V};$ $V_{IN} = V_{OUT} = V_{FR} = V_{SEn} = 0\text{ V};$ $V_{SELO,1} = 0\text{ V}; T_j = 25^\circ\text{C}$			0.5	$\mu\text{A}$
		$V_{CC} = 13\text{ V};$ $V_{IN} = V_{OUT} = V_{FR} = V_{SEn} = 0\text{ V};$ $V_{SELO,1} = 0\text{ V}; T_j = 85^\circ\text{C}$ (2)			0.5	
		$V_{CC} = 13\text{ V};$ $V_{IN} = V_{OUT} = V_{FR} = V_{SEn} = 0\text{ V};$ $V_{SELO,1} = 0\text{ V}; T_j = 125^\circ\text{C}$			3	
$t_{D\_STBY}$	Standby mode blanking time	$V_{CC} = 13\text{ V}; V_{IN} = V_{OUT} = V_{FR} = V_{SELO,1} = 0\text{ V};$ $V_{SEn} = 5\text{ V to } 5\text{ V}$	60	300	550	$\mu\text{s}$
$I_{S(ON)}$	Supply current	$V_{CC} = 13\text{ V}; V_{SEn} = 0\text{ V};$ $V_{SELO,1} = V_{FR} = 0\text{ V}; V_{IN} = 5\text{ V};$ $I_{OUT} = 0\text{ A}$		3	5	mA
$I_{GND(ON)}$	Control stage current consumption in ON-state. All channels active.	$V_{CC} = 13\text{ V}; V_{SEn} = 5\text{ V};$ $V_{FR} = V_{SELO,1} = 0\text{ V}; V_{IN} = 5\text{ V};$ $I_{OUT} = 1\text{ A}$			6	mA
$I_{L(off)}$	Off-state output current at $V_{CC} = 13\text{ V}$	$V_{IN} = V_{OUT} = 0\text{ V}; V_{CC} = 13\text{ V};$ $T_j = 25^\circ\text{C}$	0	0.01	0.5	$\mu\text{A}$
		$V_{IN} = V_{OUT} = 0\text{ V}; V_{CC} = 13\text{ V};$ $T_j = 125^\circ\text{C}$	0		3	
$V_F$	Output - $V_{CC}$ diode voltage	$I_{OUT} = -1\text{ A}; T_j = 150^\circ\text{C}$			0.7	V

**Notes:**

(1)PowerMOS leakage included.

(2)Parameter specified by design; not subjected to production test.

**Table 6: Switching**

$V_{CC} = 13\text{ V}; -40^\circ\text{C} < T_j < 150^\circ\text{C}$ , unless otherwise specified						
Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}^{(1)}$	Turn-on delay time at $T_j = 25^\circ\text{C}$	$R_L = 13\ \Omega$	10	70	120	$\mu\text{s}$
$t_{d(off)}^{(1)}$	Turn-off delay time at $T_j = 25^\circ\text{C}$		10	40	100	
$(dV_{OUT}/dt)_{on}^{(1)}$	Turn-on voltage slope at $T_j = 25^\circ\text{C}$	$R_L = 13\ \Omega$	0.1	0.27	0.7	V/ $\mu\text{s}$
$(dV_{OUT}/dt)_{off}^{(1)}$	Turn-off voltage slope at $T_j = 25^\circ\text{C}$		0.1	0.35	0.7	

V <sub>CC</sub> = 13 V; -40°C < T <sub>j</sub> < 150°C, unless otherwise specified						
Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
W <sub>ON</sub>	Switching energy losses at turn-on (t <sub>won</sub> )	R <sub>L</sub> = 13 Ω	—	0.15	0.18 <sup>(2)</sup>	mJ
W <sub>OFF</sub>	Switching energy losses at turn-off (t <sub>woff</sub> )	R <sub>L</sub> = 13 Ω	—	0.1	0.18 <sup>(2)</sup>	mJ
t <sub>SKREW</sub> <sup>(1)</sup>	Differential Pulse skew (t <sub>PHL</sub> - t <sub>PLH</sub> )	R <sub>L</sub> = 13 Ω	-100	-50	0	μs

**Notes:**

<sup>(1)</sup>See [Figure 6: "Switching time and Pulse skew"](#).

<sup>(2)</sup>Parameter guaranteed by design and characterization; not subjected to production test.

**Table 7: Logic inputs**

7 V < V <sub>CC</sub> < 28 V; -40°C < T <sub>j</sub> < 150°C						
Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
<b>INPUT characteristics</b>						
V <sub>IL</sub>	Input low level voltage				0.9	V
I <sub>IL</sub>	Low level input current	V <sub>IN</sub> = 0.9 V	1			μA
V <sub>IH</sub>	Input high level voltage		2.1			V
I <sub>IH</sub>	High level input current	V <sub>IN</sub> = 2.1 V			10	μA
V <sub>I(hyst)</sub>	Input hysteresis voltage		0.2			V
V <sub>ICL</sub>	Input clamp voltage	I <sub>IN</sub> = 1 mA	5.3		7.2	V
		I <sub>IN</sub> = -1 mA		-0.7		
<b>FaultRST characteristics (VN7140AJ only)</b>						
V <sub>FRL</sub>	Input low level voltage				0.9	V
I <sub>FRL</sub>	Low level input current	V <sub>IN</sub> = 0.9 V	1			μA
V <sub>FRH</sub>	Input high level voltage		2.1			V
I <sub>FRH</sub>	High level input current	V <sub>IN</sub> = 2.1 V			10	μA
V <sub>FR(hyst)</sub>	Input hysteresis voltage		0.2			V
V <sub>FRCL</sub>	Input clamp voltage	I <sub>IN</sub> = 1 mA	5.3		7.5	V
		I <sub>IN</sub> = -1 mA		-0.7		
<b>SEL<sub>0,1</sub> characteristics (7 V &lt; V<sub>CC</sub> &lt; 18 V) (VN7140AJ only)</b>						
V <sub>SELL</sub>	Input low level voltage				0.9	V
I <sub>SELL</sub>	Low level input current	V <sub>IN</sub> = 0.9 V	1			μA
V <sub>SELH</sub>	Input high level voltage		2.1			V
I <sub>SELH</sub>	High level input current	V <sub>IN</sub> = 2.1 V			10	μA
V <sub>SEL(hyst)</sub>	Input hysteresis voltage		0.2			V
V <sub>SELCL</sub>	Input clamp voltage	I <sub>IN</sub> = 1 mA	5.3		7.2	V
		I <sub>IN</sub> = -1 mA		-0.7		

7 V < V <sub>CC</sub> < 28 V; -40°C < T <sub>j</sub> < 150°C						
Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
<b>SEn characteristics (7 V &lt; V<sub>CC</sub> &lt; 18 V)</b>						
V <sub>SEnL</sub>	Input low level voltage				0.9	V
I <sub>SEnL</sub>	Low level input current	V <sub>IN</sub> = 0.9 V	1			μA
V <sub>SEnH</sub>	Input high level voltage		2.1			V
I <sub>SEnH</sub>	High level input current	V <sub>IN</sub> = 2.1 V			10	μA
V <sub>SEn(hyst)</sub>	Input hysteresis voltage		0.2			V
V <sub>SEnCL</sub>	Input clamp voltage	I <sub>IN</sub> = 1 mA	5.3		7.2	V
		I <sub>IN</sub> = -1 mA		-0.7		

Table 8: Protections

7 V < V <sub>CC</sub> < 18 V; -40°C < T <sub>j</sub> < 150°C						
Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
I <sub>LIMH</sub>	DC short circuit current	V <sub>CC</sub> = 13 V	8	12	16	A
		4 V < V <sub>CC</sub> < 18 V <sup>(1)</sup>				
I <sub>LIML</sub>	Short circuit current during thermal cycling	V <sub>CC</sub> = 13 V; T <sub>R</sub> < T <sub>j</sub> < T <sub>TSD</sub>		4		
T <sub>TSD</sub>	Shutdown temperature		150	175	200	°C
T <sub>R</sub>	Reset temperature <sup>(1)</sup>		T <sub>RS</sub> + 1	T <sub>RS</sub> + 7		
T <sub>RS</sub>	Thermal reset of fault diagnostic indication	V <sub>FR</sub> = 0 V; V <sub>SEn</sub> = 5 V	135			
T <sub>HYST</sub>	Thermal hysteresis(T <sub>TSD</sub> - T <sub>R</sub> ) <sup>(1)</sup>			7		
ΔT <sub>J_SD</sub>	Dynamic temperature	T <sub>j</sub> = -40°C; V <sub>CC</sub> = 13 V		60		K
t <sub>LATCH_RST</sub>	Fault reset time for output unlatch <sup>(1)</sup> (only for VN7140AJ)	V <sub>FR</sub> = 5 V to 0 V; V <sub>SEn</sub> = 5 V; V <sub>IN</sub> = 5 V; V <sub>SEL0</sub> = 0 V; V <sub>SEL1</sub> = 0 V	3	10	20	μs
V <sub>DEMAG</sub>	Turn-off output voltage clamp	I <sub>OUT</sub> = 1 A; L = 6 mH; T <sub>j</sub> = -40°C	V <sub>CC</sub> - 38			V
		I <sub>OUT</sub> = 1 A; L = 6 mH; T <sub>j</sub> = 25°C to 150°C	V <sub>CC</sub> - 41	V <sub>CC</sub> - 46	V <sub>CC</sub> - 52	V
V <sub>ON</sub>	Output voltage drop limitation	I <sub>OUT</sub> = 0.07 A		20		mV

**Notes:**

<sup>(1)</sup>Parameter guaranteed by design and characterization; not subjected to production test.

Table 9: MultiSense

7 V < V <sub>CC</sub> < 18 V; -40°C < T <sub>j</sub> < 150°C						
Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V <sub>SENSE_CL</sub>	MultiSense clamp voltage	V <sub>SEN</sub> = 0 V; I <sub>SENSE</sub> = 1 mA	-17		-12	V
		V <sub>SEN</sub> = 0 V; I <sub>SENSE</sub> = -1 mA		7		
<b>CurrentSense characteristics</b>						
K <sub>OL</sub>	I <sub>OUT</sub> /I <sub>SENSE</sub>	I <sub>OUT</sub> = 0.01 A; V <sub>SENSE</sub> = 0.5 V; V <sub>SEN</sub> = 5 V	295			
dK <sub>cal</sub> /K <sub>cal</sub> <sup>(1)(2)</sup>	Current sense ratio drift at calibration point	I <sub>OUT</sub> = 0.01 A to 0.025 A; I <sub>cal</sub> = 17.5 mA; V <sub>SENSE</sub> = 0.5 V; V <sub>SEN</sub> = 5 V	-30		30	%
K <sub>LED</sub>	I <sub>OUT</sub> /I <sub>SENSE</sub>	I <sub>OUT</sub> = 0.025 A; V <sub>SENSE</sub> = 0.5 V; V <sub>SEN</sub> = 5 V	330	580	820	
dK <sub>LED</sub> /K <sub>LED</sub> <sup>(1)(2)</sup>	Current sense ratio drift	I <sub>OUT</sub> = 0.025 A; V <sub>SENSE</sub> = 0.5 V; V <sub>SEN</sub> = 5 V	-25		25	%
K <sub>0</sub>	I <sub>OUT</sub> /I <sub>SENSE</sub>	I <sub>OUT</sub> = 0.07 A; V <sub>SENSE</sub> = 0.5 V; V <sub>SEN</sub> = 5 V	375	550	720	
dK <sub>0</sub> /K <sub>0</sub> <sup>(1)(2)</sup>	Current sense ratio drift	I <sub>OUT</sub> = 0.07 A; V <sub>SENSE</sub> = 0.5 V; V <sub>SEN</sub> = 5 V	-20		20	%
K <sub>1</sub>	I <sub>OUT</sub> /I <sub>SENSE</sub>	I <sub>OUT</sub> = 0.15 A; V <sub>SENSE</sub> = 4 V; V <sub>SEN</sub> = 5 V	360	500	670	
dK <sub>1</sub> /K <sub>1</sub> <sup>(1)(2)</sup>	Current sense ratio drift	I <sub>OUT</sub> = 0.15 A; V <sub>SENSE</sub> = 4 V; V <sub>SEN</sub> = 5 V	-15		15	%
K <sub>2</sub>	I <sub>OUT</sub> /I <sub>SENSE</sub>	I <sub>OUT</sub> = 0.7 A; V <sub>SENSE</sub> = 4 V; V <sub>SEN</sub> = 5 V	380	475	570	
dK <sub>2</sub> /K <sub>2</sub> <sup>(1)(2)</sup>	Current sense ratio drift	I <sub>OUT</sub> = 0.7 A; V <sub>SENSE</sub> = 4 V; V <sub>SEN</sub> = 5 V	-10		10	%
K <sub>3</sub>	I <sub>OUT</sub> /I <sub>SENSE</sub>	I <sub>OUT</sub> = 2 A; V <sub>SENSE</sub> = 4 V; V <sub>SEN</sub> = 5 V	430	470	520	
dK <sub>3</sub> /K <sub>3</sub> <sup>(1)(2)</sup>	Current sense ratio drift	I <sub>OUT</sub> = 2 A; V <sub>SENSE</sub> = 4 V; V <sub>SEN</sub> = 5 V	-5		5	%
I <sub>SENSE0</sub>	MultiSense leakage current	MultiSense disabled: V <sub>SEN</sub> = 0 V	0		0.5	μA
		MultiSense disabled: -1 V < V <sub>SENSE</sub> < 5 V <sup>(1)</sup>	-0.5		0.5	
		MultiSense enabled: V <sub>SEN</sub> = 5 V; Channel ON; I <sub>OUT</sub> = 0 A; Diagnostic selected; V <sub>IN</sub> = 5 V; V <sub>SEL0</sub> = 0 V; V <sub>SEL1</sub> = 0 V; I <sub>OUT</sub> = 0 A	0		2	
		MultiSense enabled: V <sub>SEN</sub> = 5 V; Channel OFF; Diagnostic selected: V <sub>IN</sub> = 0 V; V <sub>SEL0</sub> = 0 V; V <sub>SEL1</sub> = 0 V	0		2	

7 V < V <sub>CC</sub> < 18 V; -40°C < T <sub>j</sub> < 150°C						
Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V <sub>OUT_MSD</sub> <sup>(1)</sup>	Output voltage for MultiSense shutdown	V <sub>IN</sub> = 5 V; V <sub>SEn</sub> = 5 V; V <sub>SEL0</sub> = 0 V; V <sub>SEL1</sub> = 0 V; R <sub>SENSE</sub> = 2.7 kΩ; I <sub>OUT</sub> = 1 A		5		V
V <sub>SENSE_SAT</sub>	Multisense saturation voltage	V <sub>CC</sub> = 7 V; R <sub>SENSE</sub> = 2.7 kΩ; V <sub>SEn</sub> = 5 V; V <sub>IN</sub> = 5 V; V <sub>SEL0</sub> = 0 V; V <sub>SEL1</sub> = 0 V; I <sub>OUT</sub> = 2 A; T <sub>j</sub> = 150°C	5			V
I <sub>SENSE_SAT</sub> <sup>(1)</sup>	CS saturation current	V <sub>CC</sub> = 7 V; V <sub>SENSE</sub> = 4 V; V <sub>IN</sub> = 5 V; V <sub>SEn</sub> = 5 V; V <sub>SEL0</sub> = 0 V; V <sub>SEL1</sub> = 0 V; T <sub>j</sub> = 150°C	4			mA
I <sub>OUT_SAT</sub> <sup>(1)</sup>	Output saturation current	V <sub>CC</sub> = 7 V; V <sub>SENSE</sub> = 4 V; V <sub>IN</sub> = 5 V; V <sub>SEn</sub> = 5 V; V <sub>SEL0</sub> = 0 V; V <sub>SEL1</sub> = 0 V; T <sub>j</sub> = 150°C	2.2			A
<b>OFF-state diagnostic</b>						
V <sub>OL</sub>	OFF-state open-load voltage detection threshold	V <sub>IN</sub> = 0 V; V <sub>SEn</sub> = 5 V; V <sub>SEL0</sub> = 0 V; V <sub>SEL1</sub> = 0 V	2	3	4	V
I <sub>L(off2)</sub>	OFF-state output sink current	V <sub>IN</sub> = 0 V; V <sub>OUT</sub> = V <sub>OL</sub> ; T <sub>j</sub> = -40 °C to 150°C	-100		-15	μA
t <sub>DSTKON</sub>	OFF-state diagnostic delay time from falling edge of INPUT (see <a href="#">Figure 9: "TDSTKON"</a> )	V <sub>IN</sub> = 5 V to 0 V; V <sub>SEn</sub> = 5 V; V <sub>SEL0</sub> = 0 V; V <sub>SEL1</sub> = 0 V; I <sub>OUT</sub> = 0 A; V <sub>OUT</sub> = 4 V	100	350	700	μs
t <sub>D_OL_V</sub>	Settling time for valid OFF-state open load diagnostic indication from rising edge of SEn	V <sub>IN</sub> = 0 V; V <sub>FR</sub> = 0 V; V <sub>SEL0</sub> = 0 V; V <sub>SEL1</sub> = 0 V; V <sub>OUT</sub> = 4 V; V <sub>SEn</sub> = 0 V to 5 V			60	μs
t <sub>D_VOL</sub>	OFF-state diagnostic delay time from rising edge of V <sub>OUT</sub>	V <sub>IN</sub> = 0 V; V <sub>SEn</sub> = 5 V; V <sub>SEL0</sub> = 0 V; V <sub>SEL1</sub> = 0 V; V <sub>OUT</sub> = 0 V to 4 V		5	30	μs
<b>Chip temperature analog feedback (VN7140AJ only)</b>						
V <sub>SENSE_TC</sub>	MultiSense output voltage proportional to chip temperature	V <sub>SEn</sub> = 5 V; V <sub>SEL0</sub> = 0 V; V <sub>SEL1</sub> = 5 V; V <sub>IN</sub> = 0 V; R <sub>SENSE</sub> = 1 kΩ; T <sub>j</sub> = -40°C	2.325	2.41	2.495	V
		V <sub>SEn</sub> = 5 V; V <sub>SEL0</sub> = 0 V; V <sub>SEL1</sub> = 5 V; V <sub>IN</sub> = 0 V; R <sub>SENSE</sub> = 1 kΩ; T <sub>j</sub> = 25°C	1.985	2.07	2.155	V
		V <sub>SEn</sub> = 5 V; V <sub>SEL0</sub> = 0 V; V <sub>SEL1</sub> = 5 V; V <sub>IN</sub> = 0 V; R <sub>SENSE</sub> = 1 kΩ; T <sub>j</sub> = 125°C	1.435	1.52	1.605	V
dV <sub>SENSE_TC</sub> /dT <sup>(1)</sup>	Temperature coefficient	T <sub>j</sub> = -40°C to 150°C		-5.5		mV/K



7 V < V <sub>CC</sub> < 18 V; -40°C < T <sub>j</sub> < 150°C						
Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
Transfer function		$V_{SENSE\_TC}(T) = V_{SENSE\_TC}(T_0) + dV_{SENSE\_TC} / dT * (T - T_0)$				
<b>V<sub>CC</sub> supply voltage analog feedback (VN7140AJ only)</b>						
V <sub>SENSE_VCC</sub>	MultiSense output voltage proportional to V <sub>CC</sub> supply voltage	V <sub>CC</sub> = 13 V; V <sub>SEn</sub> = 5 V; V <sub>SEL0</sub> = 5 V; V <sub>SEL1</sub> = 5 V; V <sub>IN</sub> = 0 V; R <sub>SENSE</sub> = 1 kΩ	3.16	3.23	3.3	V
Transfer function <sup>(3)</sup>		$V_{SENSE\_VCC} = V_{CC} / 4$				
<b>Fault diagnostic feedback (see Table 10: "Truth table")</b>						
V <sub>SENSEH</sub>	MultiSense output voltage in fault condition	V <sub>CC</sub> = 13 V; V <sub>IN</sub> = 0 V; V <sub>SEn</sub> = 5 V; V <sub>SEL0</sub> = 0 V; V <sub>SEL1</sub> = 0 V; I <sub>OUT</sub> = 0 A; V <sub>OUT</sub> = 4 V; R <sub>SENSE</sub> = 1 kΩ;	5		6.6	V
I <sub>SENSEH</sub>	MultiSense output current in fault condition	V <sub>CC</sub> = 13 V; V <sub>SENSE</sub> = 5 V	7	20	30	mA
<b>MultiSense timings (current sense mode - see Figure 7: "MultiSense timings (current sense mode)")<sup>(4)</sup></b>						
t <sub>DSENSE1H</sub>	Current sense settling time from rising edge of SE <sub>n</sub>	V <sub>IN</sub> = 5 V; V <sub>SEn</sub> = 0 V to 5 V; R <sub>SENSE</sub> = 1 kΩ; R <sub>L</sub> = 13 Ω			60	μs
t <sub>DSENSE1L</sub>	Current sense disable delay time from falling edge of SE <sub>n</sub>	V <sub>IN</sub> = 5 V; V <sub>SEn</sub> = 5 V to 0 V; R <sub>SENSE</sub> = 1 kΩ; R <sub>L</sub> = 13 Ω		5	20	μs
t <sub>DSENSE2H</sub>	Current sense settling time from rising edge of INPUT	V <sub>IN</sub> = 0 V to 5 V; V <sub>SEn</sub> = 5 V; R <sub>SENSE</sub> = 1 kΩ; R <sub>L</sub> = 13 Ω		100	250	μs
Δt <sub>DSENSE2H</sub>	Current sense settling time from rising edge of I <sub>OUT</sub> (dynamic response to a step change of I <sub>OUT</sub> )	V <sub>IN</sub> = 5 V; V <sub>SEn</sub> = 5 V; R <sub>SENSE</sub> = 1 kΩ; I <sub>SENSE</sub> = 90 % of I <sub>SENSEMAX</sub> ; R <sub>L</sub> = 13 Ω			100	μs
t <sub>DSENSE2L</sub>	Current sense turn-off delay time from falling edge of INPUT	V <sub>IN</sub> = 5 V to 0 V; V <sub>SEn</sub> = 5 V; R <sub>SENSE</sub> = 1 kΩ; R <sub>L</sub> = 13 Ω		50	250	μs
<b>MultiSense timings (chip temperature sense mode - see Figure 8: "Multisense timings (chip temperature and VCC sense mode) (VN7140AJ only)")<sup>(4)</sup></b>						
t <sub>DSENSE3H</sub>	V <sub>SENSE_TC</sub> settling time from rising edge of SE <sub>n</sub>	V <sub>SEn</sub> = 0 V to 5 V; V <sub>SEL0</sub> = 0 V; V <sub>SEL1</sub> = 5 V; R <sub>SENSE</sub> = 1 kΩ			60	μs
t <sub>DSENSE3L</sub>	V <sub>SENSE_TC</sub> disable delay time from falling edge of SE <sub>n</sub>	V <sub>SEn</sub> = 5 V to 0 V; V <sub>SEL0</sub> = 0 V; V <sub>SEL1</sub> = 5 V; R <sub>SENSE</sub> = 1 kΩ			20	μs

7 V < V <sub>CC</sub> < 18 V; -40°C < T <sub>j</sub> < 150°C						
Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
<b>MultiSense timings (V<sub>CC</sub> voltage sense mode - see Figure 8: "Multisense timings (chip temperature and V<sub>CC</sub> sense mode) (VN7140AJ only)" (VN7140AJ only)<sup>(4)</sup></b>						
t <sub>DSENSE4H</sub>	V <sub>SENSE_VCC</sub> settling time from rising edge of SEn	V <sub>SEn</sub> = 0 V to 5 V; V <sub>SEL0</sub> = 5 V; V <sub>SEL1</sub> = 5 V; R <sub>SENSE</sub> = 1 kΩ			60	μs
t <sub>DSENSE4L</sub>	V <sub>SENSE_VCC</sub> disable delay time from falling edge of SEn	V <sub>SEn</sub> = 5 V to 0 V; V <sub>SEL0</sub> = 5 V; V <sub>SEL1</sub> = 5 V; R <sub>SENSE</sub> = 1 kΩ			20	μs
<b>MultiSense timings (Multiplexer transition times) (VN7140AJ only)<sup>(4)</sup></b>						
t <sub>D_CStoTC</sub>	MultiSense transition delay from current sense to T <sub>C</sub> sense	V <sub>IN</sub> = 5 V; V <sub>SEn</sub> = 5 V; V <sub>SEL0</sub> = 0 V; V <sub>SEL1</sub> = 0 V to 5 V; I <sub>OUT</sub> = 0.5 A; R <sub>SENSE</sub> = 1 kΩ			60	μs
t <sub>D_TCtoCS</sub>	MultiSense transition delay from T <sub>C</sub> sense to current sense	V <sub>IN</sub> = 5 V; V <sub>SEn</sub> = 5 V; V <sub>SEL0</sub> = 0 V; V <sub>SEL1</sub> = 5 V to 0 V; I <sub>OUT</sub> = 0.5 A; R <sub>SENSE</sub> = 1 kΩ			20	μs
t <sub>D_CStoVCC</sub>	MultiSense transition delay from current sense to V <sub>CC</sub> sense	V <sub>IN</sub> = 5 V; V <sub>SEn</sub> = 5 V; V <sub>SEL0</sub> = 5 V; V <sub>SEL1</sub> = 0 V to 5 V; I <sub>OUT</sub> = 0.5 A; R <sub>SENSE</sub> = 1 kΩ			60	μs
t <sub>D_VCCtoCS</sub>	MultiSense transition delay from V <sub>CC</sub> sense to current sense	V <sub>IN</sub> = 5 V; V <sub>SEn</sub> = 5 V; V <sub>SEL0</sub> = 5 V; V <sub>SEL1</sub> = 5 V to 0 V; I <sub>OUT</sub> = 0.5 A; R <sub>SENSE</sub> = 1 kΩ			20	μs
t <sub>D_TCtoVCC</sub>	MultiSense transition delay from T <sub>C</sub> sense to V <sub>CC</sub> sense	V <sub>CC</sub> = 13 V; T <sub>j</sub> = 125°C; V <sub>SEn</sub> = 5 V; V <sub>SEL0</sub> = 0 V to 5 V; V <sub>SEL1</sub> = 5 V; R <sub>SENSE</sub> = 1 kΩ			20	μs
t <sub>D_VCCtoTC</sub>	MultiSense transition delay from V <sub>CC</sub> sense to T <sub>C</sub> sense	V <sub>CC</sub> = 13 V; T <sub>j</sub> = 125°C; V <sub>SEn</sub> = 5 V; V <sub>SEL0</sub> = 5 V to 0 V; V <sub>SEL1</sub> = 5 V; R <sub>SENSE</sub> = 1 kΩ			20	μs

**Notes:**

- (1)Parameter specified by design; not subjected to production test.  
(2)All values refer to V<sub>CC</sub> = 13 V; T<sub>j</sub> = 25°C, unless otherwise specified.  
(3)V<sub>CC</sub> sensing and T<sub>C</sub> are referred to GND potential.  
(4)Transition delays are measured up to +/- 10% of final conditions.

Figure 4: IO<sub>UT</sub>/ISENSE versus IO<sub>UT</sub>

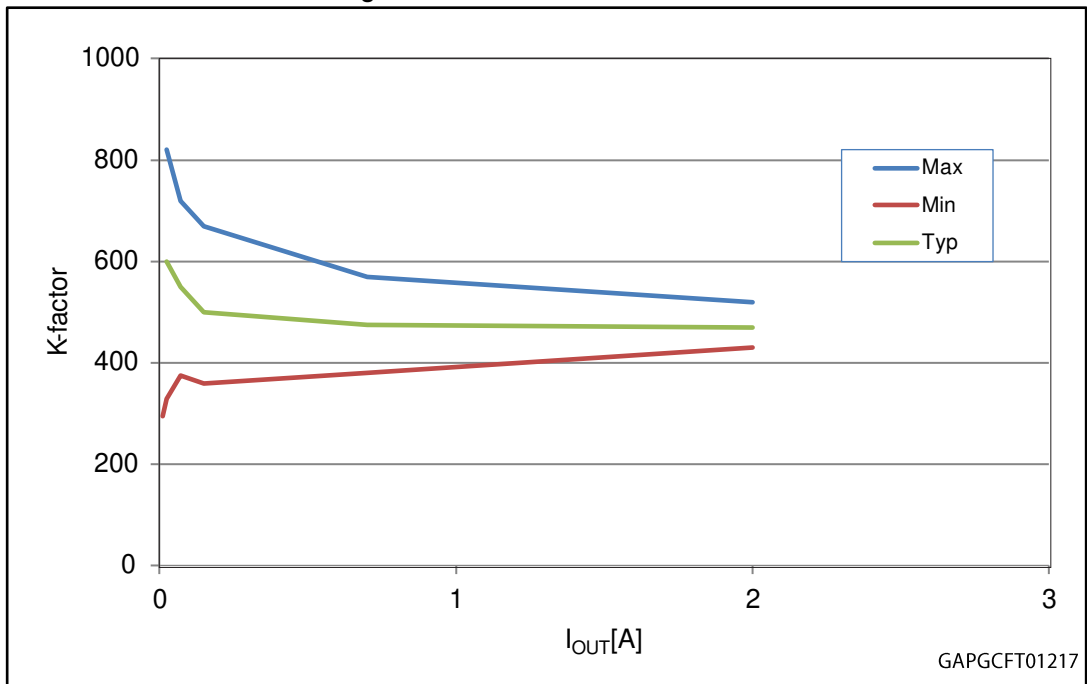


Figure 5: Current sense accuracy versus IO<sub>UT</sub>

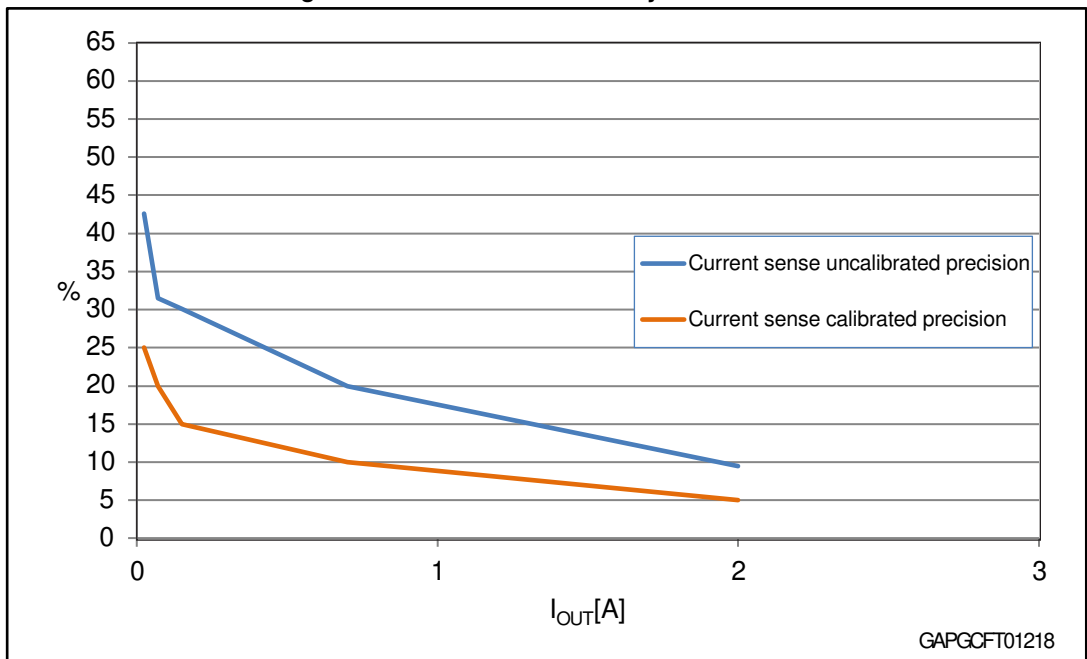


Figure 6: Switching time and Pulse skew

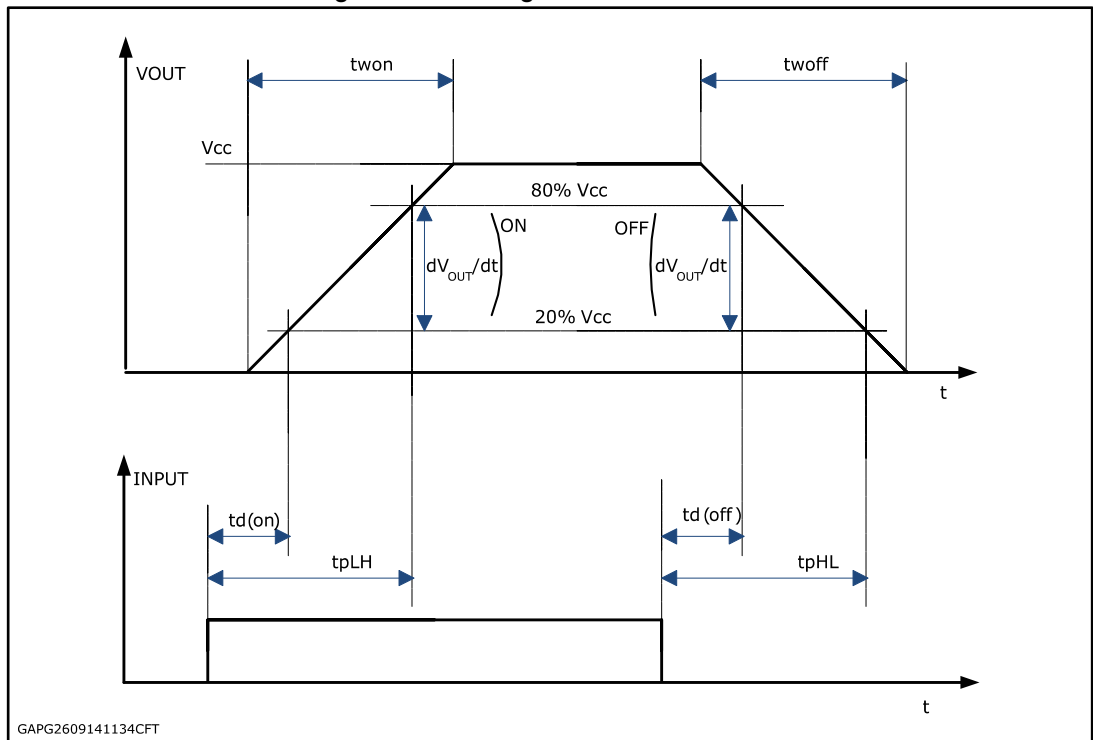


Figure 7: MultiSense timings (current sense mode)

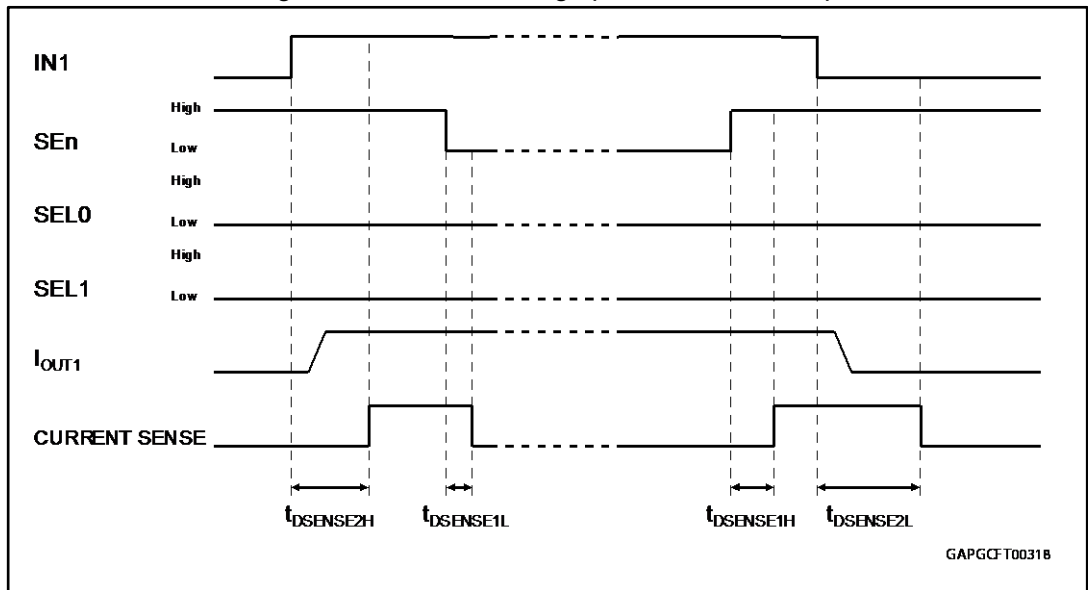


Figure 8: Multisense timings (chip temperature and VCC sense mode) (VN7140AJ only)

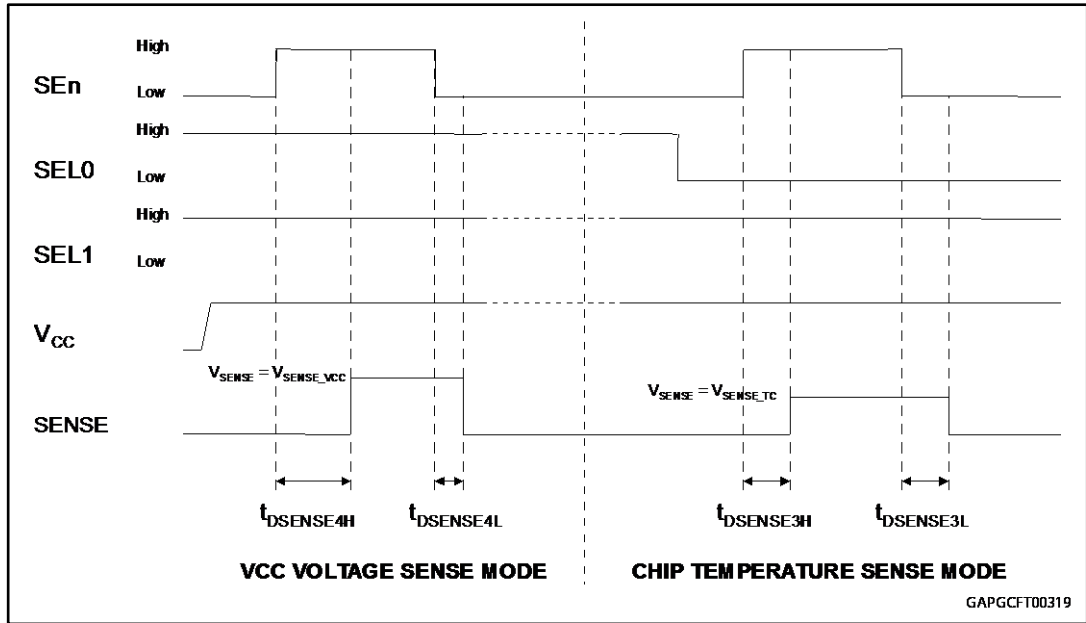


Figure 9: TDSTKON

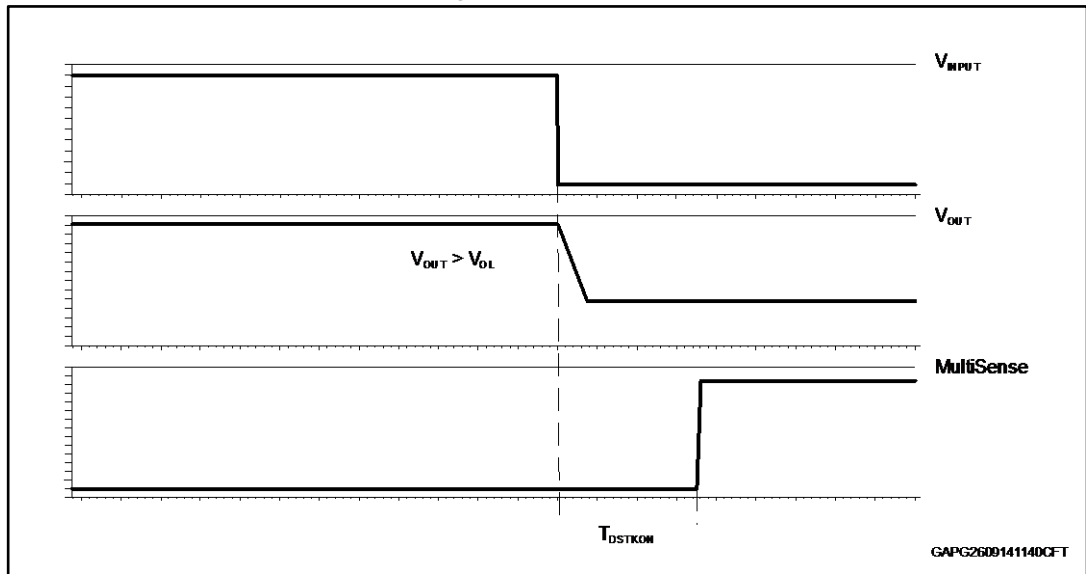


Table 10: Truth table

Mode	Conditions	IN <sub>x</sub>	FR <sup>(1)</sup>	SEn	SEL <sub>x</sub> <sup>(1)</sup>	OUT <sub>x</sub>	MultiSense	Comments
Standby	All logic inputs low	L	L	L	L	L	Hi-Z	Low quiescent current consumption
Normal	Nominal load connected; T <sub>j</sub> < 150 °C	L	X	See <sup>(2)</sup>		L	See <sup>(2)</sup>	Outputs configured for auto-restart
		H	L			H	See <sup>(2)</sup>	

Mode	Conditions	IN <sub>x</sub>	FR <sup>(1)</sup>	SEn	SEL <sub>x</sub> <sup>(1)</sup>	OUT <sub>x</sub>	MultiSense	Comments
		H	H			H	See <sup>(2)</sup>	Outputs configured for latch-off <sup>(1)</sup>
Overload	Overload or short to GND causing: T <sub>j</sub> > T <sub>TSD</sub> or ΔT <sub>j</sub> > ΔT <sub>I_SD</sub>	L	X	See <sup>(2)</sup>		L	See <sup>(2)</sup>	
		H	L			H	See <sup>(2)</sup>	Output cycles with temperature hysteresis
		H	H			L	See <sup>(2)</sup>	Output latches-off <sup>(1)</sup>
Undervoltage	V <sub>CC</sub> < V <sub>USD</sub> (falling)	X	X	X	X	L L	Hi-Z Hi-Z	Re-start when V <sub>CC</sub> > V <sub>USD</sub> + V <sub>USDhyst</sub> (rising)
OFF-state diagnostics	Short to V <sub>CC</sub>	L	X	See <sup>(2)</sup>		H	See <sup>(2)</sup>	
	Open-load	L	X			H	See <sup>(2)</sup>	External pull-up
Negative output voltage	Inductive loads turn-off	L	X	See <sup>(2)</sup>		< 0 V	See <sup>(2)</sup>	

**Notes:**

<sup>(1)</sup>VN7140AJ only

<sup>(2)</sup>Refer to [Table 11: "MultiSense multiplexer addressing"](#)

**Table 11: MultiSense multiplexer addressing**

SEn	SEL <sub>1</sub>	SEL <sub>0</sub>	MUX channel	MultiSense output			
				Normal mode	Overload	OFF-state diag. <sup>(1)</sup>	Negative output
SO-8							
L	N.A.	N.A.	N.A.	Hi-Z			
H	N.A.	N.A.	Channel diagnostic	I <sub>SENSE</sub> = 1/K * I <sub>OUT</sub>	V <sub>SENSE</sub> = V <sub>SENSEH</sub>	V <sub>SENSE</sub> = V <sub>SENSEH</sub>	Hi-Z
PowerSSO-16							
H	L	L	Channel diagnostic	I <sub>SENSE</sub> = 1/K * I <sub>OUT</sub>	V <sub>SENSE</sub> = V <sub>SENSEH</sub>	V <sub>SENSE</sub> = V <sub>SENSEH</sub>	Hi-Z
H	L	H	Channel diagnostic	I <sub>SENSE</sub> = 1/K * I <sub>OUT</sub>	V <sub>SENSE</sub> = V <sub>SENSEH</sub>	V <sub>SENSE</sub> = V <sub>SENSEH</sub>	Hi-Z
H	H	L	T <sub>CHIP</sub> Sense	V <sub>SENSE</sub> = V <sub>SENSE_TC</sub>			
H	H	H	V <sub>CC</sub> Sense	V <sub>SENSE</sub> = V <sub>SENSE_VCC</sub>			

**Notes:**

<sup>(1)</sup>In case the output channel corresponding to the selected MUX channel is latched off while the relevant input is low, Multisense pin delivers feedback according to OFF-State diagnostic. Example 1: FR = 1; IN = 0; OUT = L (latched); MUX channel = channel 0 diagnostic; Mutisense = 0. Example 2: FR = 1; IN = 0; OUT = latched, V<sub>OUT</sub> > V<sub>OL</sub>; MUX channel = channel 0 diagnostic; Mutisense = V<sub>SENSEH</sub>

## 2.4 Waveforms

Figure 10: Latch functionality - behavior in hard short circuit condition ( $T_{AMB} \ll T_{TSD}$ )

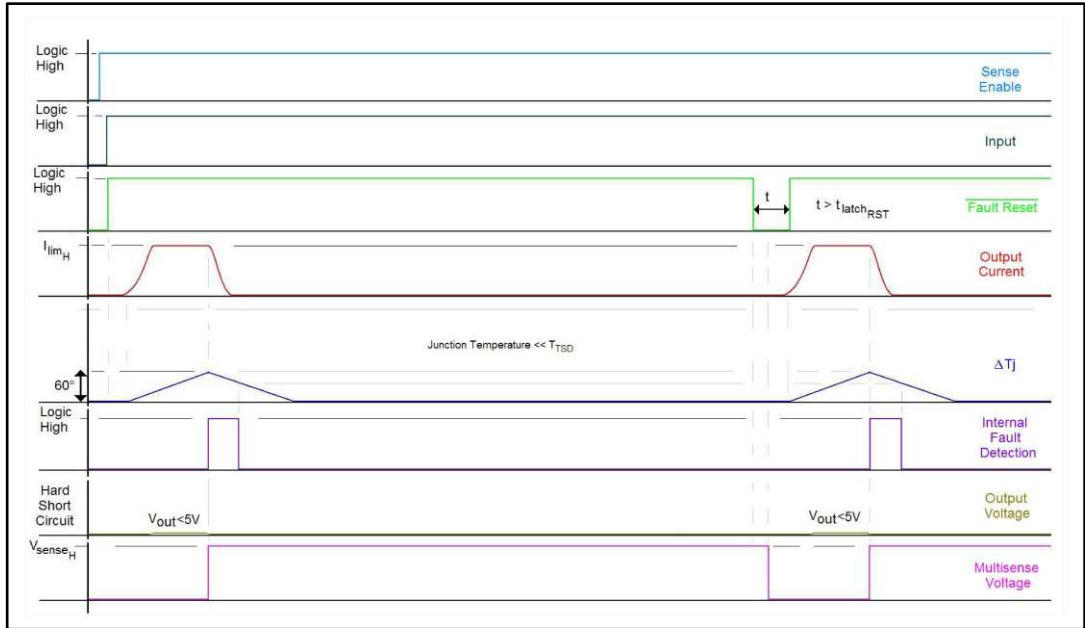


Figure 11: Latch functionality - behavior in hard short circuit condition

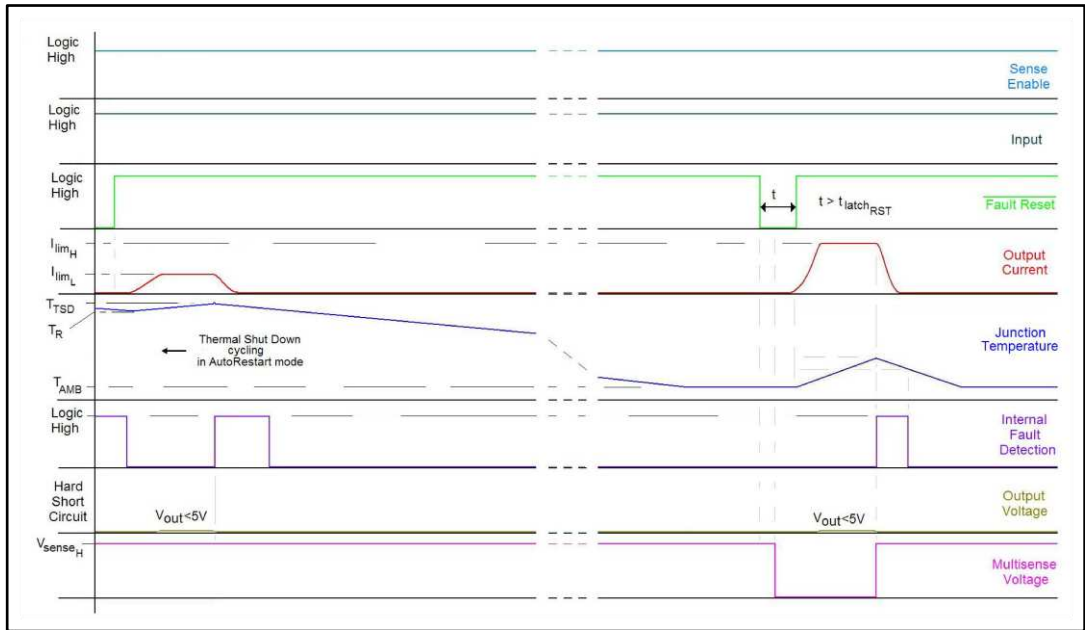


Figure 12: Latch functionality - behavior in hard short circuit condition (autorestart mode + latch off)

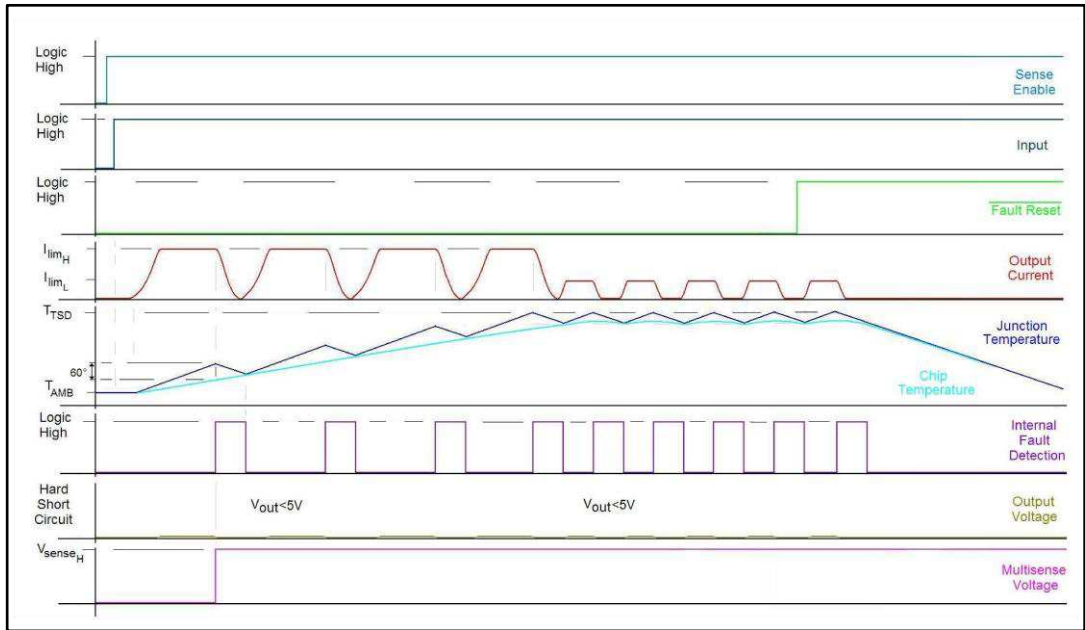


Figure 13: Standby mode activation

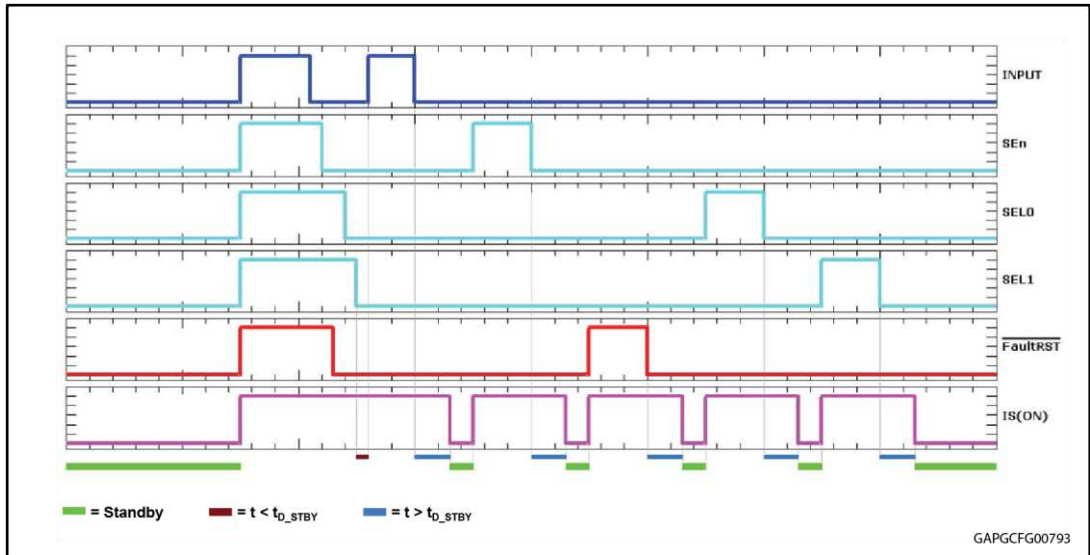
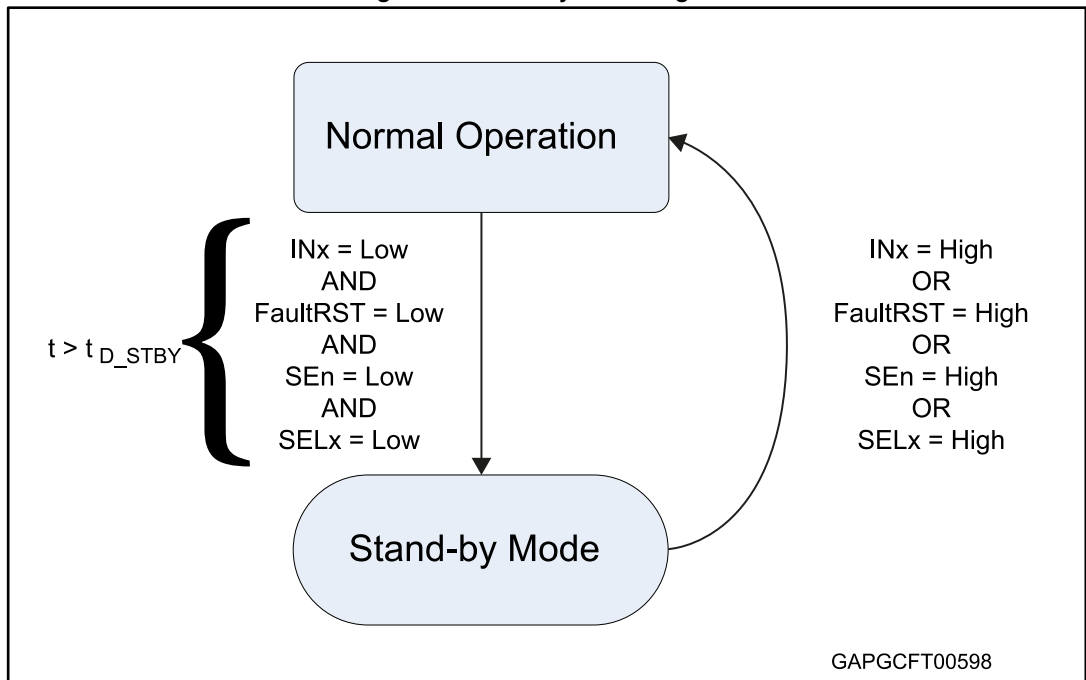




Figure 14: Standby state diagram



## 2.5 Electrical characteristics curves

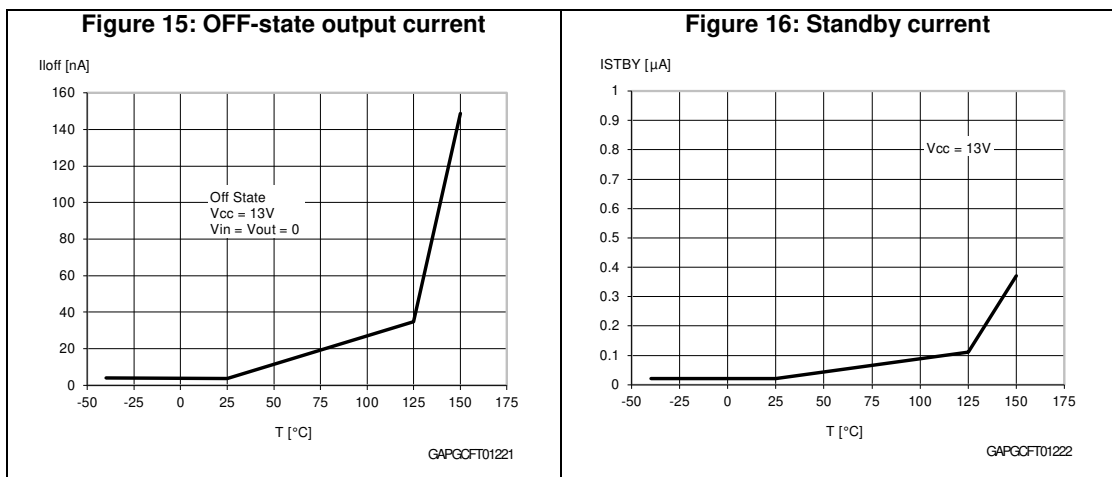


Figure 17: IGND(ON) vs. Tcase

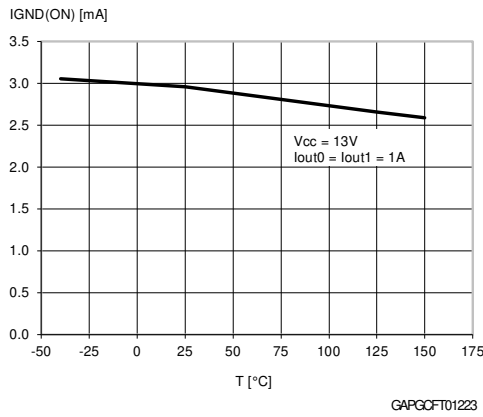


Figure 18: Logic Input high level voltage

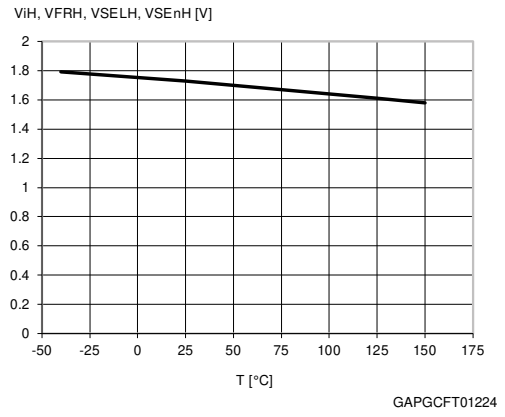


Figure 19: Logic Input low level voltage

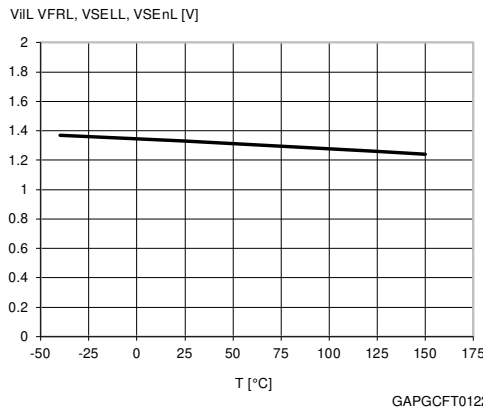


Figure 20: High level logic input current

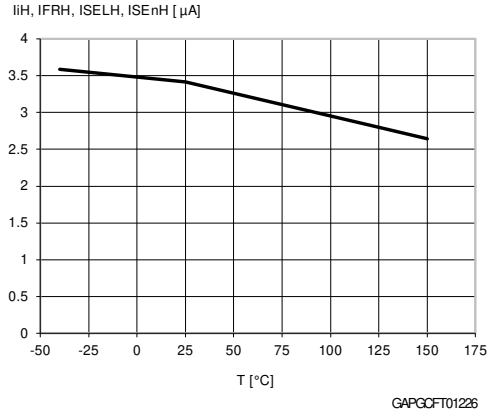


Figure 21: Low level logic input current

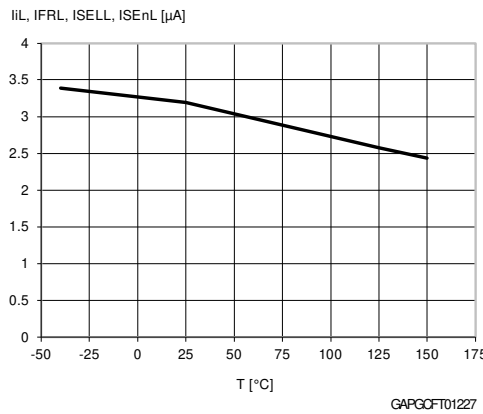


Figure 22: Logic Input hysteresis voltage

