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VNQ7040AY-E

life.augmented

Quad channel high-side driver with MultiSense analog feedback for automotive applications

Datasheet - production data

PowerSSO-36

Features

Max transient supply voltage	V_{CC}	41 V
Operating voltage range	V_{CC}	4 to 28 V
Typ. on-state resistance (per ch)	R_{ON}	40 mΩ
Current limitation (typ)	I_{LIMH}	34 A
Standby current (max)	I_{STBY}	0.5 µA

- General
  - Quad channel smart high-side driver with MultiSense analog feedback
  - LED Mode for channel 0 and 1
  - 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; 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
  - Loss of ground and loss of V_{CC}
  - Reverse battery through self turn-on
  - Electrostatic discharge protection

Applications

- All types of Automotive resistive, inductive and capacitive loads
- Specially intended for Automotive Turn Indicators (up to P27W or SAE1156 and R5W paralleled or LED Rear Combinations)

Description

The VNQ7040AY-E is a quad channel high-side driver manufactured using the latest ST proprietary VIPower® technology and housed in PowerSSO-36 package. The device is 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 device integrates 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 such as 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.

The device features a dedicated LED Mode.

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1 Block diagram and pin description

Figure 1. Block diagram

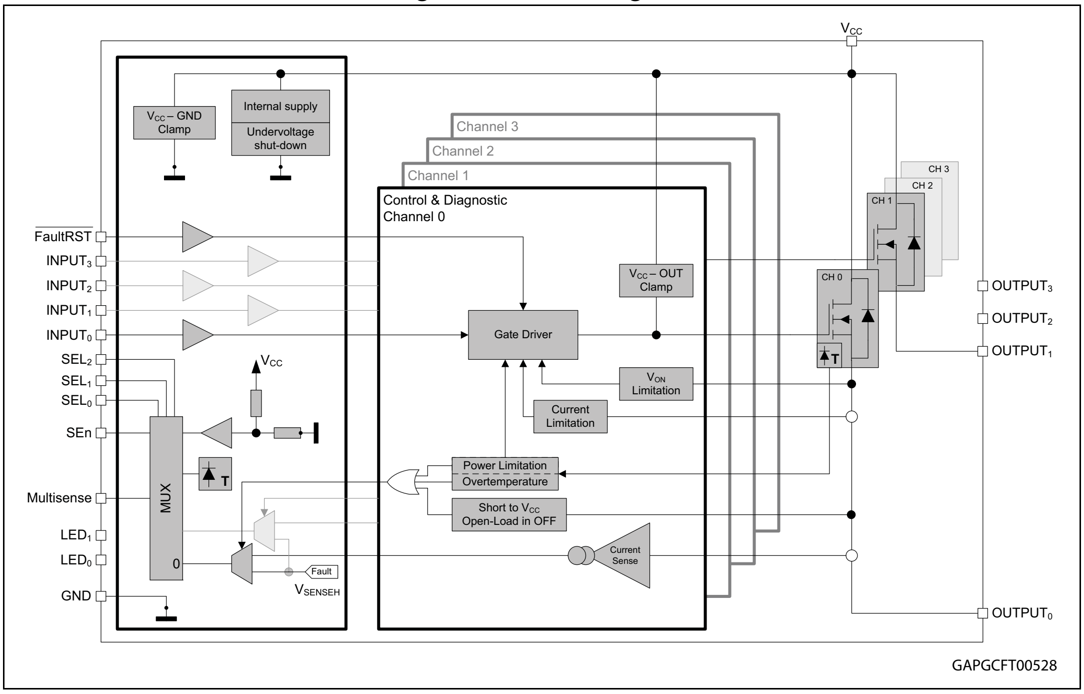


Table 1. Pin functions

Name	Function
V_{CC}	Battery connection.
$OUTPUT_{0,1,2,3}$	Power output.
GND	Ground connection.
$INPUT_{0,1,2,3}$	Voltage controlled input pin with hysteresis, compatible with 3 V and 5 V CMOS outputs. They control 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
$LED_{0,1}$	Active high compatible with 3 V and 5 V CMOS outputs pin; they enable the LED mode on logic high level (see *Table 15: Truth table*).
$SEL_{0,1,2}$	Active high compatible with 3 V and 5 V CMOS outputs pin; they address the MultiSense multiplexer (see *Table 15: Truth table*).
$\overline{FaultRST}$	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)

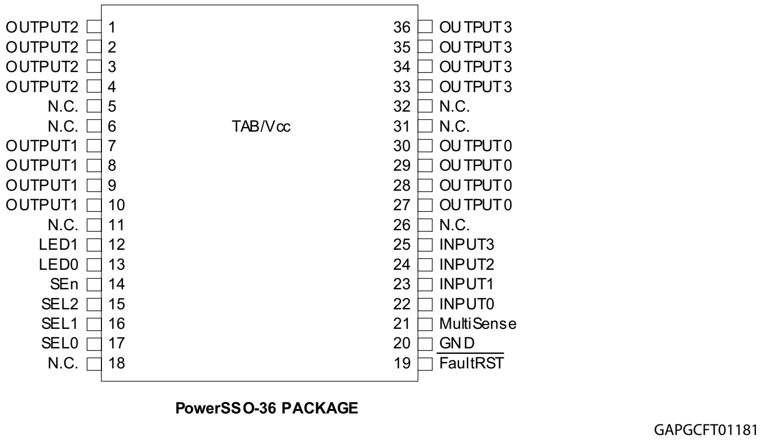


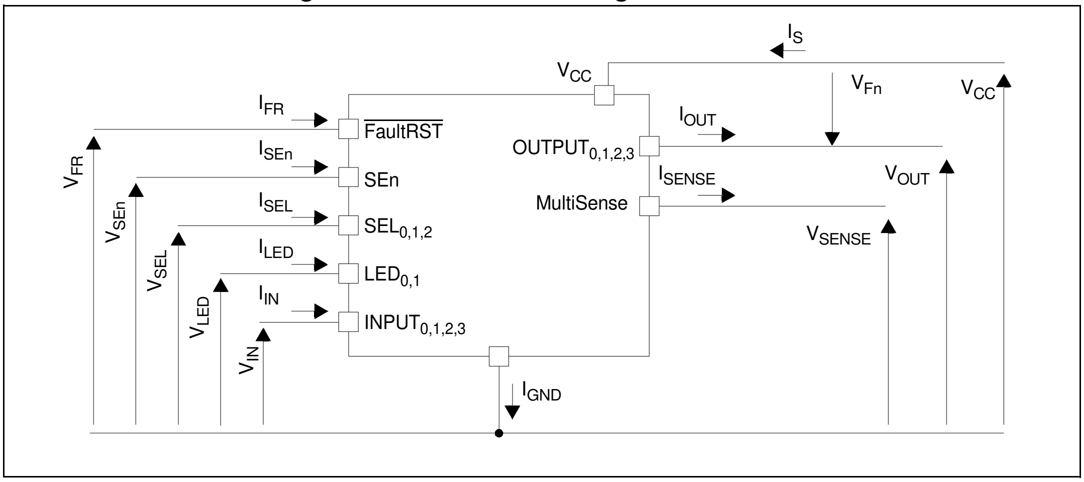
Table 2. Suggested connections for unused and not connected pins

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

1. X: do not care.

2 Electrical specification

Figure 3. Current and voltage conventions



1. $V_{Fn} = V_{OUTn} - V_{CC}$

2.1 Absolute maximum ratings

Stressing the device above the rating listed in *Table 3* 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	16	
V_{CCPK}	Maximum transient supply voltage (ISO7637-2:2004 Pulse 5b level IV clamped to 40 V; R_L = 4 Ω)	40	
V_{CCJS}	Maximum jump start voltage for single pulse short circuit protection	28	
$-I_{GND}$	DC reverse ground pin current	200	mA
I_{OUT}	OUTPUT$_{0,1,2,3}$ DC output current	Internally limited	A
$-I_{OUT\_0,1}$	OUTPUT$_{0,1}$ Reverse DC output current	10	
$-I_{OUT\_2,3}$	OUTPUT$_{2,3}$ Reverse DC output current	10	
I_{IN}	INPUT$_{0,1,2,3}$ DC input current	-1 to 10	mA
I_{LED}	LED$_{0,1}$ DC input current		
I_{SEn}	SEn DC input current		
I_{SEL}	SEL$_{0,1,2}$ DC input current		
I_{FR}	FaultRST DC input current	-1 to 10	mA

Table 3. Absolute maximum ratings (continued)

Symbol	Parameter	Value	Unit
V_{FR}	FaultRST DC input voltage	7.5	V
I_{SENSE}	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	mA
E_{MAX}	Maximum switching energy (single pulse) (T_{DEMAG} = 0.4 ms; T_{jstart} = 150 °C)	36	mJ
V_{ESD}	Electrostatic discharge (JEDEC 22A-114F) – $INPUT_{0,1,2,3}$ – MultiSense – $LED_{0,1}$, SEn, $SEL_{0,1,2}$, $\overline{\text{FaultRST}}$ – $OUTPUT_{0,1,2,3}$ – V_{CC}	 4000 2000 4000 4000 4000	 V V V V V
V_{ESD}	Charge device model (CDM-AEC-Q100-011)	750	V
T_j	Junction operating temperature	-40 to 150	°C
T_{stg}	Storage temperature	-55 to 150	

2.2 Thermal data

Table 4. Thermal data

Symbol	Parameter	Typ. value	Unit
$R_{thj\text{-}board}$	Thermal resistance junction-board (JEDEC JESD 51-5 / 51-8)(1)(2)	4.9	°C/W
$R_{thj\text{-}amb}$	Thermal resistance junction-ambient (JEDEC JESD 51-5)(1)(3)	52.5	
$R_{thj\text{-}amb}$	Thermal resistance junction-ambient (JEDEC JESD 51-7)(1)(2)	18	

1. One channel ON.
2. Device mounted on four-layers 2s2p PCB
3. Device mounted on two-layers 2s0p PCB with 2 cm^2 heatsink copper trace

2.3 Electrical characteristics

7 V < V_{CC} < 28 V; -40 °C < T_j < 150 °C, unless otherwise specified.

All typical values refer to V_{CC} = 13 V; T_j = 25 °C, unless otherwise specified.

2.3.1 General electrical specification

Table 5. Power section

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{CC}	Operating supply voltage		4	13	28	V
V_{USD}	Undervoltage shutdown				4	
$V_{USDReset}$	Undervoltage shutdown reset				5	
$V_{USDhyst}$	Undervoltage shutdown hysteresis			0.3		
V_{clamp}	Clamp voltage	I_S = 20 mA; 25 °C < T_j < 150 °C	41	46	52	V
		I_S = 20 mA; T_j = -40 °C	38			V
I_{STBY}	Supply current in standby at V_{CC} = 13 V(1)	V_{CC} = 13 V; V_{INx} = V_{OUTx} = V_{FR} = V_{SEn} = 0 V; $V_{SEL0,1,2}$ = 0 V; $V_{LED0,1}$ = 0 V; T_j = 25 °C			0.5	µA
		V_{CC} = 13 V; V_{INx} = V_{OUTx} = V_{FR} = V_{SEn} = 0 V; $V_{SEL0,1,2}$ = 0 V; $V_{LED0,1}$ = 0 V; T_j = 85 °C(2)			0.5	µA
		V_{CC} = 13 V; V_{INx} = V_{OUTx} = V_{FR} = V_{SEn} = 0 V; $V_{SEL0,1,2}$ = 0 V; $V_{LED0,1}$ = 0 V; T_j = 125 °C;			3	µA
t_{D_STBY}	Standby mode blanking time	V_{CC} = 13 V; V_{INx} = V_{OUTx} = V_{FR} = 0 V; $V_{SEL0,1,2}$ = 0 V; $V_{LED0,1}$ = 0 V; V_{SEn} = 5 V to 0 V	60	300	550	µs
$I_{S(ON)}$	Supply current	V_{CC} = 13 V; V_{SEn} = V_{FR} = $V_{SEL0,1}$ = 0 V; V_{INx} = 5 V; $I_{OUT0,1,2,3}$ = 0 A;		10	16	mA
$I_{GND(ON)}$	Control stage current consumption in ON state. All channels active.	V_{CC} = 13 V; V_{SEn} = 5 V; V_{FR} = $V_{SEL0,1}$ = 0 V; V_{INx} = 5 V; $I_{OUT0,1,2,3}$ = 2.5 A			18.5	mA
$I_{L(off)}$	Off-state output current at V_{CC} = 13 V(1)	V_{INx} = V_{OUTx} = 0 V; V_{CC} = 13 V; T_j = 25 °C	0	0.01	0.5	µA
		V_{INx} = V_{OUTx} = 0 V; V_{CC} = 13 V; T_j = 125 °C	0		3	
V_F	Output - V_{CC} diode voltage(3)	I_{OUT} = -2.5 A; T_j = 150 °C			0.7	V

1. PowerMOS leakage included.

2. Parameter specified by design; not subject to production test.
3. For each channel.

Table 6. Logic Inputs (7 V < V_{CC} < 28 V; -40 °C < T_j < 150 °C)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$INPUT_{0,1,2,3}$ characteristics						
V_{IL}	Input low level voltage				0.9	V
I_{IL}	Low level input current	V_{IN} = 0.9 V	1			µA
V_{IH}	Input high level voltage		2.1			V
I_{IH}	High level input current	V_{IN} = 2.1 V			10	µA
$V_{I(hyst)}$	Input hysteresis voltage		0.2			V
V_{ICL}	Input clamp voltage	I_{IN} = 1 mA	5.3		7.2	V
		I_{IN} = -1 mA		-0.7		
$\overline{FaultRST}$ characteristics						
V_{FRL}	Input low level voltage				0.9	V
I_{FRL}	Low level input current	V_{IN} = 0.9 V	1			µA
V_{FRH}	Input high level voltage		2.1			V
I_{FRH}	High level input current	V_{IN} = 2.1 V			10	µA
$V_{FR(hyst)}$	Input hysteresis voltage		0.2			V
V_{FRCL}	Input clamp voltage	I_{IN} = 1 mA	5.3		7.5	V
		I_{IN} = -1 mA		-0.7		
$SEL_{0,1,2}$ characteristics (7 V < V_{CC} < 18 V)						
V_{SELL}	Input low level voltage				0.9	V
I_{SELL}	Low level input current	V_{IN} = 0.9 V	1			µA
V_{SELH}	Input high level voltage		2.1			V
I_{SELH}	High level input current	V_{IN} = 2.1 V			10	µA
$V_{SEL(hyst)}$	Input hysteresis voltage		0.2			V
V_{SELCL}	Input clamp voltage	I_{IN} = 1 mA	5.3		7.2	V
		I_{IN} = -1 mA		-0.7		
$LED_{0,1}$ characteristics (7 V < V_{CC} < 18 V)						
V_{LEDL}	Input low level voltage				0.9	V
I_{LEDL}	Low level input current	V_{IN} = 0.9 V	1			µA
V_{LEDH}	Input high level voltage		2.1			V
I_{LEDH}	High level input current	V_{IN} = 2.1 V			10	µA
$V_{LED(hyst)}$	Input hysteresis voltage		0.2			V

Table 6. Logic Inputs (7 V < V_{CC} < 28 V; -40 °C < T_j < 150 °C) (continued)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{LEDCL}	Input clamp voltage	I_{IN} = 1 mA	5.3		7.2	V
		I_{IN} = -1 mA		-0.7		
SEn characteristics (7 V < V_{CC} < 18 V)						
V_{SEnL}	Input low level voltage				0.9	V
I_{SEnL}	Low level input current	V_{IN} = 0.9 V	1			µA
V_{SEnH}	Input high level voltage		2.1			V
I_{SEnH}	High level input current	V_{IN} = 2.1 V			10	µA
$V_{SEn(hyst)}$	Input hysteresis voltage		0.2			V
V_{SEnCL}	Input clamp voltage	I_{IN} = 1 mA	5.3		7.2	V
		I_{IN} = -1 mA		-0.7		

Table 7. Protections (7 V < V_{CC} < 18 V; -40 °C < T_j < 150 °C)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
T_{TSD}	Shutdown temperature		150	175	200	°C
T_R	Reset temperature(1)		T_{RS} + 1	T_{RS} + 5		
T_{RS}	Thermal reset of fault diagnostic indication	V_{FR} = 0 V; V_{SEn} =5 V	135			
T_{HYST}	Thermal hysteresis (T_{TSD}-T_R)(1)			5		
ΔT_{J_SD}	Dynamic temperature			60		K
t_{LATCH_RST}	Fault reset time for output unlatch(1)	V_{FR} = 5 V to 0 V; V_{SEn} = 5 V; V_{INx} = 5 V; $V_{SEL0,1,2}$ = 0 V	3	10	20	µs
V_{DEMAG}	Turn-off output voltage clamp	I_{OUT}= 2 A; L = 6 mH; T_j = -40 °C	V_{CC} - 38			V
		I_{OUT}= 2 A; L = 6 mH; T_j = 25 °C to 150 °C	V_{CC} - 41	V_{CC} - 46	V_{CC} - 52	V
V_{ON}	Output voltage drop limitation	I_{OUT}= 0.25 A		20		mV

1. Parameter guaranteed by design and characterization; not subject to production test.

Table 8. MultiSense (7 V < V_{CC} < 18 V; -40 °C < T_j < 150 °C)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{SENSE_CL}	MultiSense clamp voltage	V_{SEn} = 0 V; I_{SENSE} = 1 mA	-17		-12	V
		V_{SEn} = 0 V; I_{SENSE} = -1 mA		-0.7		V
Current Sense characteristics						
I_{SENSE0}	MultiSense leakage current	MultiSense disabled: V_{SEn} = 0 V;	0		0.5	µA
		MultiSense disabled: -1 V < V_{SENSE} < 5 V(1)	-0.5		0.5	
		MultiSense enabled: V_{SEn} = 5 V All channels ON; I_{OUTX} = 0 A; Ch_X diagnostic selected; – E.G. Ch_0: V_{IN0} = 5 V; $V_{IN1,2,3}$ = 5 V; $V_{SEL0,1,2}$ = 0 V; I_{OUT0} = 0 A; $I_{OUT1,2,3}$ = 2.5 A	0		2	
		MultiSense enabled: V_{SEn} = 5 V Ch_X OFF; Ch_X diagnostic selected: – E.G. Ch_0: V_{IN0} = 0 V; $V_{IN1,2,3}$ = 5 V; $V_{SEL0,1,2}$ = 0 V; I_{OUT0} = 0 A; $I_{OUT1,2,3}$ = 2.5 A	0		2	
V_{OUT_MSD}(1)	Output Voltage for MultiSense shutdown	V_{SEn} = 5 V; R_{SENSE} = 2.7 kΩ – E.g. Ch_0: V_{IN0} = 5 V; $V_{SEL0,1,2}$ = 0 V; I_{OUT0} = 2.5 A		5		V
V_{SENSE_SAT}	Multisense saturation voltage	V_{CC} = 7 V; R_{SENSE} = 2.7 K; V_{SEn} = 5 V; V_{IN0} = 5 V; $V_{SEL0,1,2}$ = 0 V; I_{OUT0} = 4.5 A; T_j = 150°C	5			V
I_{SENSE_SAT}(1)	CS saturation current	V_{CC} = 7 V; V_{SENSE} = 4 V; V_{IN0} = 5 V; V_{SEn} = 5 V; $V_{SEL0,1,2}$ = 0 V; T_j = 150°C	4			mA
$I_{OUT\_SAT\_BULB}$(1)	Output saturation current in BULB mode	V_{CC} = 7 V; V_{SENSE} = 4 V; V_{IN0} = 5 V; V_{SEn} = 5 V; $V_{SEL0,1,2}$ = 0 V; T_j = 150°C	8			A
$I_{OUT\_SAT\_LED}$(1)	Output saturation current in LED mode	V_{CC} = 7 V; V_{SENSE} = 4 V; V_{IN0} = 5 V; V_{SEn} = 5 V; $V_{SEL0,1,2}$ = 0 V; T_j = 150°C	2.3			A
OFF-state diagnostic						
V_{OL}	OFF state open load voltage detection threshold	V_{SEn} = 5V; Ch_X OFF; Ch_X diagnostic selected – E.G: Ch_0 V_{IN0} = 0 V; $V_{SEL0,1,2}$ = 0 V	2	3	4	V
$I_{L(off2)}$	OFF state output sink current	V_{IN} = 0 V; V_{OUT} = V_{OL}; T_j = -40°C to 125°C	-100		-15	µA

Table 8. MultiSense (7 V < V_{CC} < 18 V; -40 °C < T_j < 150 °C) (continued)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
t_{DSTKON}	OFF state diagnostic delay time from falling edge of INPUT (see *Figure 35*)	V_{SEn} = 5 V; Ch_X ON to OFF transition; Ch_X diagnostic selected – E.G: Ch_0 V_{IN0} = 5 V to 0 V; $V_{SEL0,1,2}$ = 0 V; V_{OUT0} > 4 V	100	350	700	µs
$t_{D\_OL\_V}$	Settling time for valid OFF-state open load diagnostic indication from rising edge of SEn	V_{INx} = 0 V; V_{FR} = 0 V; $V_{SEL0,1,2}$ = 0 V; V_{OUT0} = 4 V; V_{SEn} = 0 V to 5 V			60	µs
t_{D_VOL}	OFF state diagnostic delay time from rising edge of V_{OUT}	V_{SEn} = 5V; Ch_X OFF; Ch_X diagnostic selected – E.G: Ch_0 V_{IN0} = 0 V; $V_{SEL0,1,2}$ = 0 V; V_{OUT0} = 0 V to 4 V		5	30	µs
Chip temperature analog feedback						
V_{SENSE_TC}	MultiSense output voltage proportional to chip temperature	V_{SEn} = 5 V; V_{SEL0} = 0 V; V_{SEL1} = 0 V; V_{SEL2} = 5 V; R_{SENSE} = 1 KΩ; V_{INx} = 0 V; T_j = -40°C	2.325	2.41	2.495	V
		V_{SEn} = 5 V; V_{SEL0} = 0 V; V_{SEL1} = 0 V; V_{SEL2} = 5 V; R_{SENSE} = 1 KΩ; V_{INx} = 0 V; T_j = 25°C	1.985	2.07	2.155	V
		V_{SEn} = 5 V; V_{SEL0} = 0 V; V_{SEL1} = 0 V; V_{SEL2} = 5 V; R_{SENSE} = 1 KΩ; V_{INx} = 0 V; T_j = 125°C	1.435	1.52	1.605	V
dV_{SENSE_TC}/dT(2)	Temperature coefficient	T_j = -40°C to 150°C		-5.5		mV/K
Transfer function		$V_{SENSE\_TC}(T) = V_{SENSE\_TC}(T_0) + dV_{SENSE\_TC}/dT * (T-T_0)$				
V_{CC} supply voltage analog feedback						
V_{SENSE_VCC}	MultiSense output voltage proportional to V_{CC} supply voltage	V_{CC} = 13 V; V_{SEn} = 5 V; $V_{SEL0,1,2}$ = 5 V; V_{INx} = 0 V; R_{SENSE} = 1 KΩ	3.16	3.23	3.3	V
Transfer function(2)		$V_{SENSE\_VCC} = V_{CC} / 4$				
Fault diagnostic feedback (see *Table 15*)						
V_{SENSEH}	MultiSense output voltage in fault condition(	V_{CC} = 13 V; R_{SENSE} = 1 kΩ	5		6.6	V
I_{SENSEH}	MultiSense output current in fault condition	V_{CC} = 13 V; V_{SENSE} = 5 V	7	20	30	mA
MultiSense timings (Chip Temperature Sense mode - see *Figure 37*)						
$t_{DSENSE3H}$	V_{SENSE_TC} settling time from rising edge of SEn	V_{SEn} = 0 V to 5 V; V_{SEL0} = V_{SEL1} = 0 V; V_{SEL2} = 5 V; R_{SENSE} = 1 kΩ			60	µs

Table 8. MultiSense (7 V < V_{CC} < 18 V; -40 °C < T_j < 150 °C) (continued)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{DSENSE3L}$	V_{SENSE_TC} disable delay time from falling edge of SEn	V_{SEn} = 5 V to 0 V; V_{SEL0} = V_{SEL1} = 0 V; V_{SEL2} = 5 V; R_{SENSE} = 1 kΩ			20	µs
MultiSense timings (V_{CC} Voltage Sense mode - see *Figure 37*)						
$t_{DSENSE4H}$	V_{SENSE_VCC} settling time from rising edge of SEn	V_{SEn} = 0 V to 5 V; V_{SEL0} = V_{SEL1} = V_{SEL2} = 5 V; R_{SENSE} = 1 kΩ			60	µs
$t_{DSENSE4L}$	V_{SENSE_VCC} disable delay time from falling edge of SEn	V_{SEn} = 5 V to 0 V; V_{SEL0} = V_{SEL1} = V_{SEL2} = 5 V; R_{SENSE} = 1 kΩ			20	µs
MultiSense Timings (Multiplexer transition times)(3)						
t_{D_XtoY}	MultiSense transition delay from Ch_X to Ch_Y	V_{IN2} = 5 V; V_{IN3} = 5 V; V_{SEn} = 5 V; V_{SEL0} = 0 V to 5 V; V_{SEL1} = 5 V; V_{SEL2} = 0 V; I_{OUT2} = 0 A; I_{OUT3} = 2.5 A; R_{SENSE} = 1 kΩ			20	µs
t_{D_CStoTC}	MultiSense transition delay from current sense to T_C sense	V_{IN0} = 5 V; V_{SEn} = 5 V; V_{SEL0} = 0 V; V_{SEL1} = V_{SEL2} = 0 V to 5 V; I_{OUT0} = 1.25 A; R_{SENSE} = 1 kΩ			60	µs
t_{D_TCtoCS}	MultiSense transition delay fromT_C sense to current sense	V_{IN0} = 5 V; V_{SEn} = 5 V; V_{SEL0} = 0 V; V_{SEL1} = V_{SEL2} = 5 V to 0 V; I_{OUT0} = 1.25 A; R_{SENSE} = 1 kΩ			20	µs
$t_{D\_CStoVCC}$	MultiSense transition delay from current sense to V_{CC} sense	V_{IN2} = 5 V; V_{SEn} = 5 V; V_{SEL0} = 5 V; V_{SEL1} = 5 V; V_{SEL2} = 0 V to 5 V; I_{OUT2} = 1.25 A; R_{SENSE} = 1 kΩ			60	µs
$t_{D\_VCCtoCS}$	MultiSense transition delay from V_{CC} sense to current sense	V_{IN2} = 5 V; V_{SEn} = 5 V; V_{SEL1} = 5 V; V_{SEL0} = V_{SEL2} = 5 V to 0 V; I_{OUT2} = 1.25 A; R_{SENSE} = 1 kΩ			20	µs
$t_{D\_TCtoVCC}$	MultiSense transition delay from T_C sense to V_{CC} sense	V_{SEn} = 5 V; $V_{SEL1,2}$ = 5 V; V_{SEL0} = 0 V to 5 V; R_{SENSE} = 1 kΩ			20	µs
$t_{D\_VCCtoTC}$	MultiSense transition delay from V_{CC} sense to T_C sense	V_{SEn} = 5 V; $V_{SEL1,2}$ = 5 V; V_{SEL0} = 5 V to 0 V; R_{SENSE} = 1 kΩ			20	µs
$t_{D\_CStoVSENSEH}$	MultiSense transition delay from stable current sense on Ch_X to V_{SENSEH} on Ch_Y	V_{IN0} = 5 V; V_{IN1} = 0 V; V_{OUT1} > 4 V; V_{SEn} = 5 V; V_{SEL2} = 0 V; V_{SEL1} = 0 V; V_{SEL0} = 0 V to 5 V; I_{OUT0} = 2.5 A; R_{SENSE} = 1 kΩ			60	µs

1. Parameter guaranteed by design and characterization; not subject to production test.
2. V_{CC} sensing and T_C sensing are referred to GND potential.
3. Transition delay are measured up to +/- 10% of final conditions.

2.3.2 Bulb mode (default)

Table 9. Power section in Bulb Mode (7 V < V_{CC} < 28 V; -40 °C < T_j < 150 °C, unless otherwise specified)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$R_{ON\_0,1,2,3\_BULB}$	On-state resistance in Bulb Mode Ch0, Ch1, Ch2 and Ch3	I_{OUT} = 2.5 A; T_j = 25°C		40		mΩ
		I_{OUT} = 2.5 A; T_j = 150°C			80	
		I_{OUT} = 2.5 A; V_{CC} = 4 V; T_j = 25°C			60	
$R_{ON\_REV\_0,1,2,3}$	On-state resistance in Reverse Battery Ch0, Ch1, Ch2 and Ch3	V_{CC} = -13V; I_{OUT} = -2.5A; T_j = 25°C		40		mΩ
$I_{LIMH\_0,1,2,3\_BULB}$(1)	DC short circuit current in Bulb Mode Ch0, Ch1, Ch2 and Ch3	V_{CC} = 13 V	24	34	48	A
		4 V < V_{CC} < 18 V(2)			48	
$I_{LIML\_0,1,2,3\_BULB}$	Short circuit current during thermal cycling in Bulb Mode Ch0, Ch1, Ch2 and Ch3	V_{CC} = 13 V; T_R < T_j < T_{TSD}		9		
$V_{ON\_0,1,2,3\_BULB}$	Output voltage drop limitation in Bulb Mode Ch0, Ch1, Ch2 and Ch3	I_{OUT} = 0.25 A		20		mV

1. Parameter guaranteed by an indirect test sequence.
2. Parameter guaranteed by design and characterization; not subject to production test.

Table 10. Switching in Bulb Mode (V_{CC} = 13 V; -40 °C < T_j < 150 °C, unless otherwise specified)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
Channel 0, 1, 2 and 3						
$t_{d(on)\_0,1,2,3}$(1)	Turn-on delay time at T_j = 25 °C	R_L = 5.2 Ω	10	60	120	µs
$t_{d(off)\_0,1,2,3}$(1)	Turn-off delay time at T_j = 25 °C	R_L = 5.2 Ω	10	50	100	
$(dV_{OUT}/dt)_{on\_0,1,2,3}$(1)	Turn-on voltage slope at T_j = 25 °C	R_L = 5.2 Ω	0.1	0.5	0.7	V/µs
$(dV_{OUT}/dt)_{off\_0,1,2,3}$(1)	Turn-off voltage slope at T_j = 25 °C	R_L = 5.2 Ω	0.1	0.5	0.7	
$W_{ON\_0,1,2,3}$	Switching energy losses at turn-on (t_{won})	R_L = 5.2 Ω	—	0.2	0.52(2)	mJ

Table 10. Switching in Bulb Mode (V_{CC} = 13 V; -40 °C < T_j < 150 °C, unless otherwise specified) (continued)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$W_{OFF\_0,1,2,3}$	Switching energy losses at turn-off (t_{woff})	R_L = 5.2 Ω	—	0.2	0.5(2)	mJ
$t_{SKEW\_0,1,2,3}$(1)	Differential pulse skew (t_{PHL} - t_{PLH})	R_L = 5.2 Ω	-65	-15	35	µs

1. See *Figure 35: Switching times and Pulse skew*.
2. Parameter guaranteed by design and characterization, not subject to production test.

Table 11. MultiSense in Bulb Mode (7 V < V_{CC} < 18 V; -40 °C < T_j < 150 °C)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
Current sense characteristics						
Channel 0, 1, 2 and 3						
$K_{OL\_CH0,1\_B}$	I_{OUT}/I_{SENSE}	I_{OUT} = 10 mA; V_{SENSE} = 0.5 V; V_{SEn} = 5 V	430			
$K_{OL\_CH2,3\_B}$	I_{OUT}/I_{SENSE}	I_{OUT} = 10 mA; V_{SENSE} = 0.5 V; V_{SEn} = 5 V	430			
dK_{cal}/K_{cal}(1)(2)	Current sense ratio drift at calibration point	I_{CAL} = 30 mA; I_{OUT} = 10 mA to 50 mA; V_{SENSE} = 0.5 V; V_{SEn} = 5 V	-35		35	%
$K_{LED\_CH0,1\_B}$	I_{OUT}/I_{SENSE}	I_{OUT} = 0.05 A; V_{SENSE} = 0.5 V; V_{SEn} = 5 V	720	1440	2160	
$K_{LED\_CH2,3\_B}$	I_{OUT}/I_{SENSE}	I_{OUT} = 0.05 A; V_{SENSE} = 0.5 V; V_{SEn} = 5 V	720	1440	2160	
$K_{0\_CH0,1\_B}$	I_{OUT}/I_{SENSE}	I_{OUT} = 0.25 A; V_{SENSE} = 0.5 V; V_{SEn} = 5 V	930	1550	2170	
$K_{0\_CH2,3\_B}$	I_{OUT}/I_{SENSE}	I_{OUT} = 0.25 A; V_{SENSE} = 0.5 V; V_{SEn} = 5 V	930	1550	2170	
dK_0/K_0(1)(2)	Current sense ratio drift	I_{OUT} = 0.25 A; V_{SENSE} = 0.5 V; V_{SEn} = 5 V	-20		20	%
$K_{1\_CH0,1\_B}$	I_{OUT}/I_{SENSE}	I_{OUT} = 0.5 A; V_{SENSE} = 4 V; V_{SEn} = 5 V	1110	1590	2070	
$K_{1\_CH2,3\_B}$	I_{OUT}/I_{SENSE}	I_{OUT} = 0.5 A; V_{SENSE} = 4 V; V_{SEn} = 5 V	1085	1550	2015	
dK_1/K_1(1)(2)	Current sense ratio drift	I_{OUT} = 0.5 A; V_{SENSE} = 4V; V_{SEn} = 5 V	-15		15	%
$K_{2\_CH0,1\_B}$	I_{OUT}/I_{SENSE}	I_{OUT} = 2 A; V_{SENSE} = 4 V; V_{SEn} = 5 V	1160	1450	1740	
$K_{2\_CH2,3\_B}$	I_{OUT}/I_{SENSE}	I_{OUT} = 2 A; V_{SENSE} = 4 V; V_{SEn} = 5 V	1130	1410	1690	

Table 11. MultiSense in Bulb Mode (7 V < V_{CC} < 18 V; -40 °C < T_j < 150 °C) (continued)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
dK_2/K_2 (1)(2)	Current sense ratio drift	I_{OUT} = 2 A; V_{SENSE} = 4 V; V_{SEn} = 5 V	-10		10	%
$K_{3\_CH0,1\_B}$	I_{OUT}/I_{SENSE}	I_{OUT} = 6 A; V_{SENSE} = 4 V; V_{SEn} = 5 V	1295	1440	1585	
$K_{3\_CH2,3\_B}$	I_{OUT}/I_{SENSE}	I_{OUT} = 6 A; V_{SENSE} = 4 V; V_{SEn} = 5 V	1260	1400	1540	
dK_3/K_3 (1)(2)	Current sense ratio drift	I_{OUT} = 6 A; V_{SENSE} = 4 V; V_{SEn} = 5 V	-5		5	%
MultiSense timings (Current Sense mode see *Figure 36*)						
Channel 0, 1, 2 and 3						
$t_{DSENSE1H}$	Current sense settling time from rising edge of SEn	V_{IN} = 5 V; V_{SEn} = 0 V to 5 V; R_{SENSE} = 1 kΩ; R_L = 5.2 Ω			60	µs
$t_{DSENSE1L}$	Current sense disable delay time from falling edge of SEn	V_{SEn} = 5 V to 0 V; R_{SENSE} = 1 kΩ; R_L = 5.2 Ω		5	20	µs
$t_{DSENSE2H}$	Current sense settling time from rising edge of INPUT	V_{IN} = 0 V to 5 V; V_{SEn} = 5 V; R_{SENSE} = 1 kΩ; R_L = 5.2 Ω		100	250	µs
$\Delta t_{DSENSE2H}$	Current sense settling time from rising edge of I_{OUT} (dynamic response to a step change of I_{OUT})	V_{IN} = 5 V; V_{SEn} = 5 V; R_{SENSE} = 1 kΩ; R_L = 5.2 Ω			100	µs
$t_{DSENSE2L}$	Current sense turn-off delay time from falling edge of INPUT	V_{IN} = 5 V to 0 V; V_{SEn} = 5 V; R_{SENSE} = 1 kΩ; R_L = 5.2 Ω		50	250	µs

1. Parameter specified by design; not subject to production test.
2. All values refer to V_{CC} = 13 V; T_j = 25 °C, unless otherwise specified.

Figure 4. Bulb Mode - I_{OUT}/I_{SENSE} versus I_{OUT}

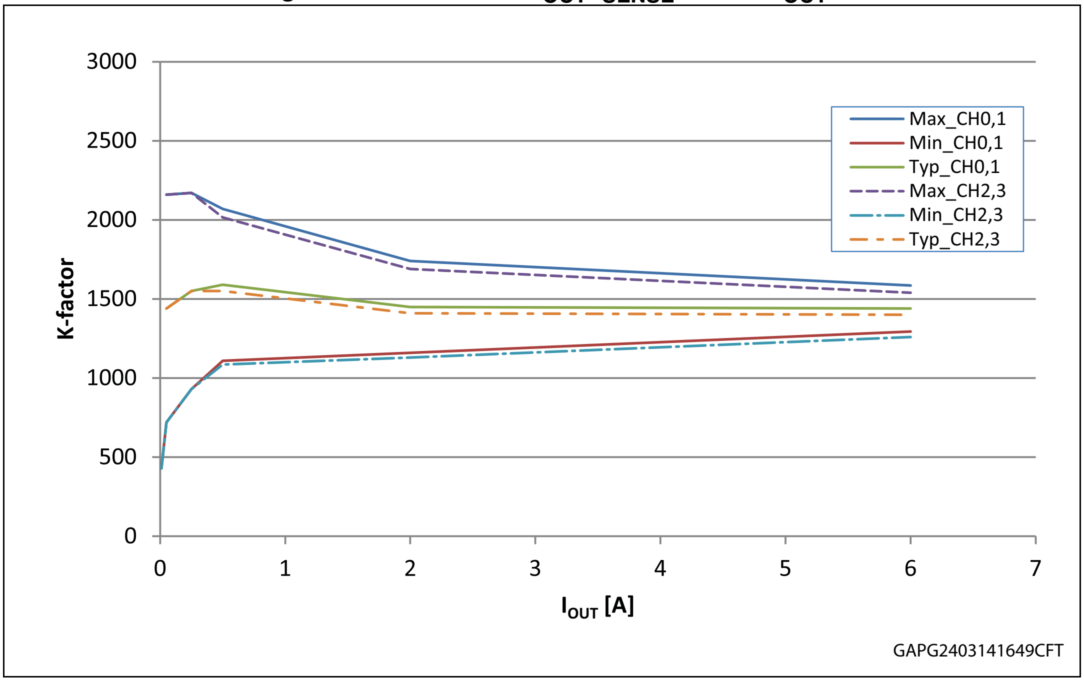
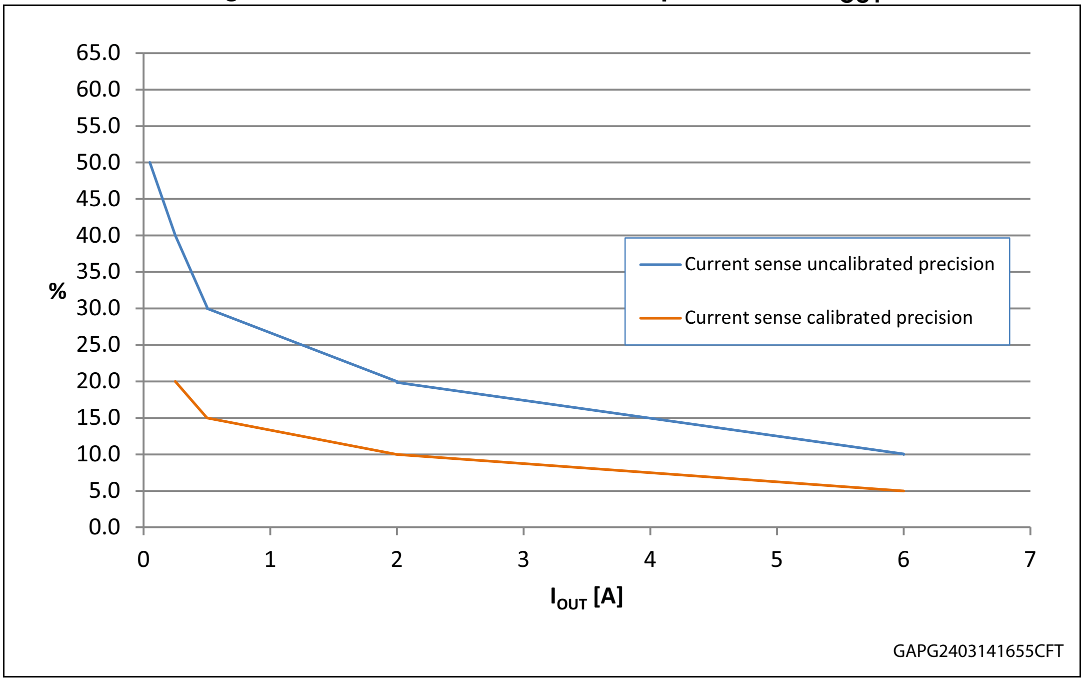


Figure 5. Bulb Mode - current sense precision vs. I_{OUT}



2.4 Electrical characteristics curves - Bulb Mode

Figure 6. OFF-state output current

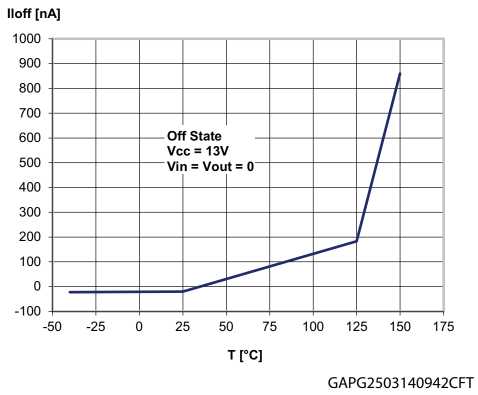


Figure 7. Standby current

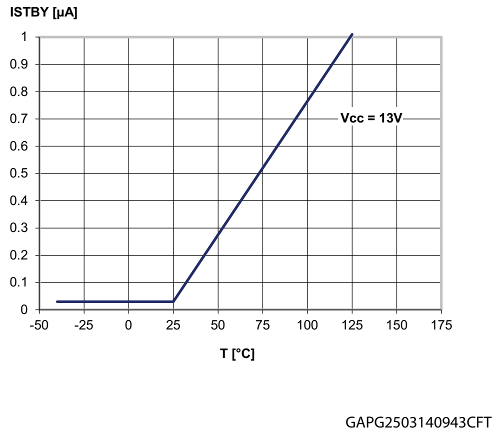


Figure 8. $I_{GND(ON)}$ vs. I_{out}

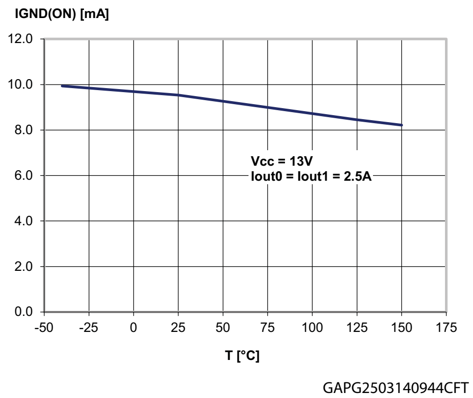


Figure 9. Logic Input high level voltage

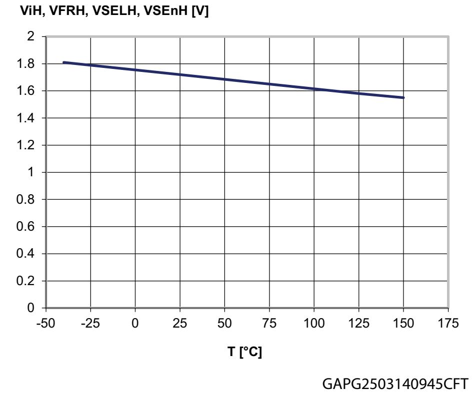


Figure 10. Logic Input low level voltage

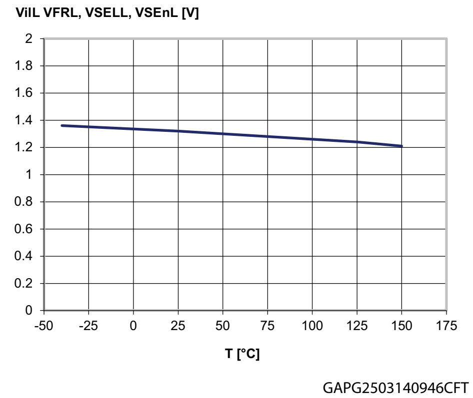


Figure 11. High level logic input current

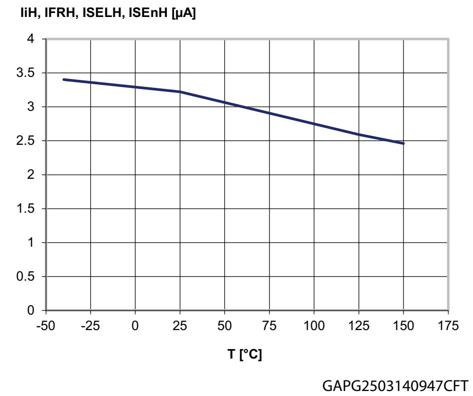


Figure 12. Low level logic input current

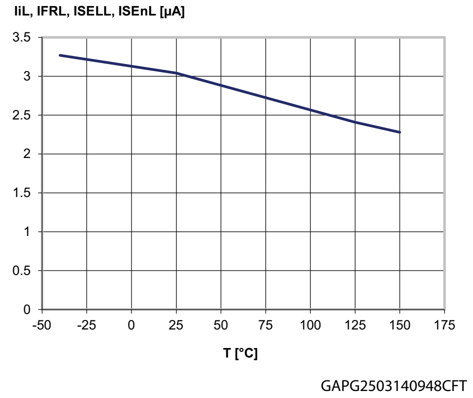


Figure 13. Logic Input hysteresis voltage

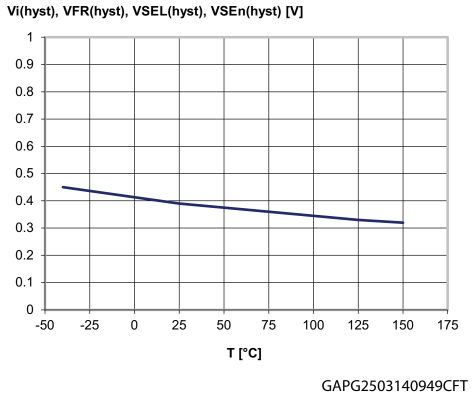


Figure 14. FaultRST Input clamp voltage

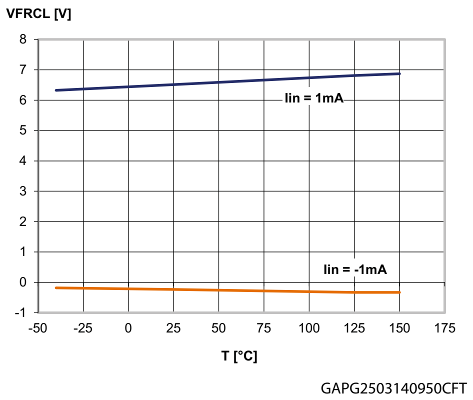


Figure 15. Undervoltage shutdown

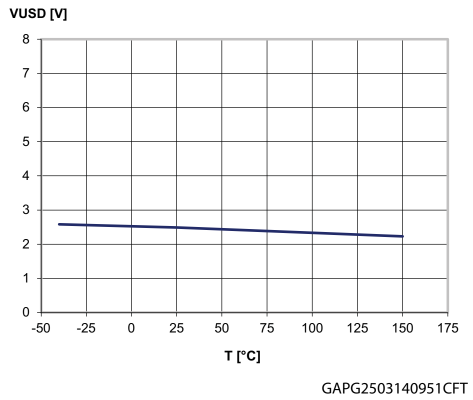


Figure 16. On-state resistance vs. T_{case}

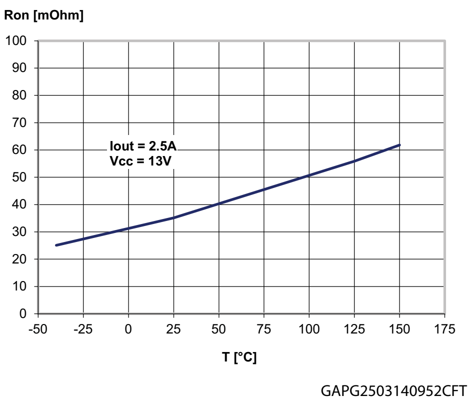


Figure 17. On-state resistance vs. V_{CC}

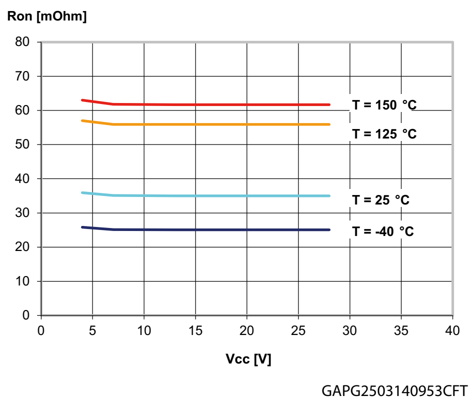


Figure 18. Turn-on voltage slope

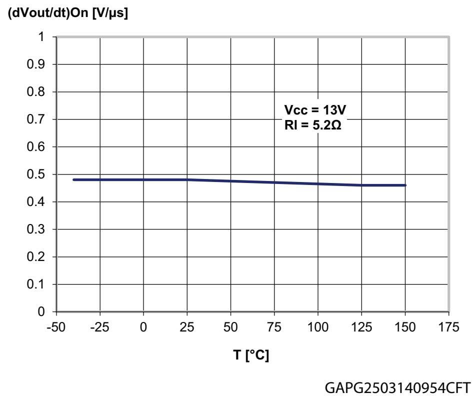


Figure 19. Turn-off voltage slope

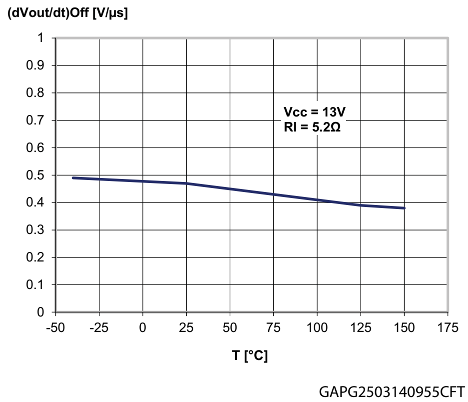


Figure 20. Won vs. T_{case}

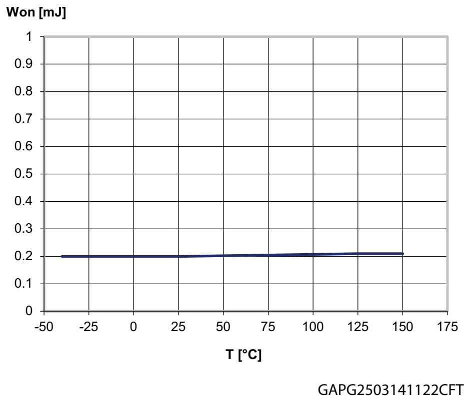


Figure 21. Woff vs. T_{case}

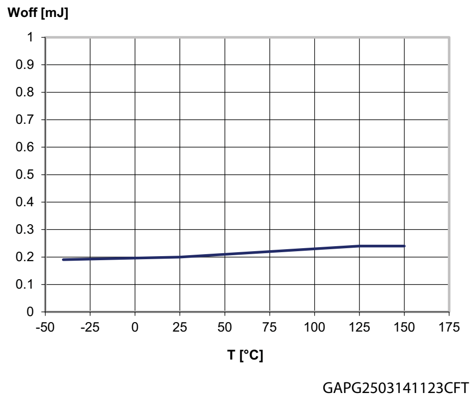


Figure 22. I_{LIMH} vs. T_{case}

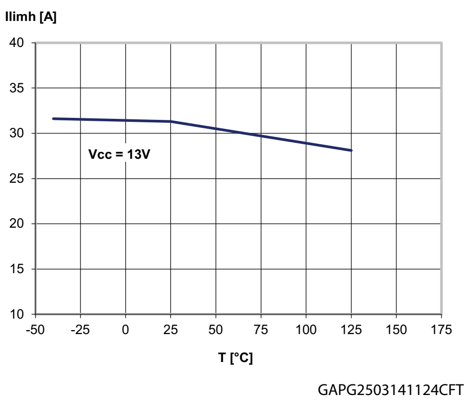


Figure 23. OFF-state open-load voltage detection threshold

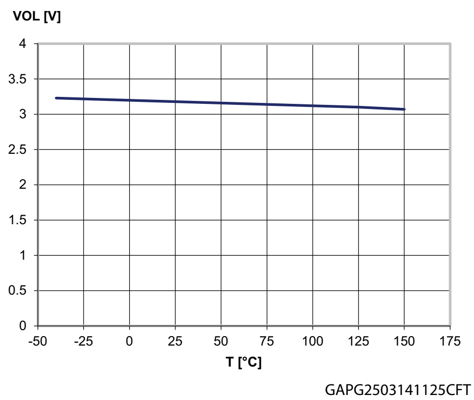


Figure 24. V_{sense} clamp vs. T_{case}

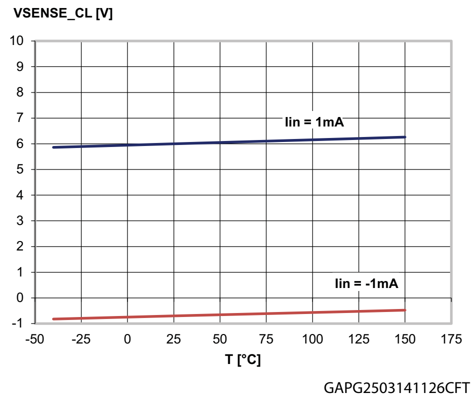
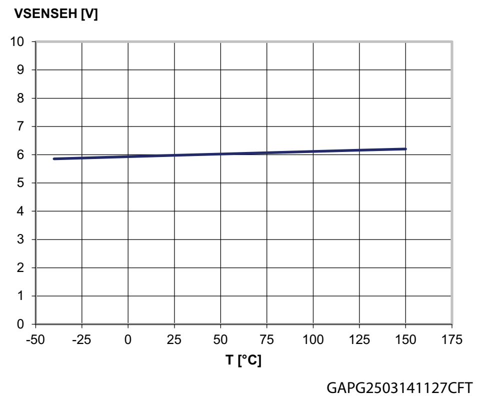


Figure 25. V_{senseh} vs. T_{case}



2.4.1 LED Mode (Channel 0 and 1)

Table 12. Switching in LED Mode (V_{CC} = 13 V; -40 °C < T_j < 150 °C, unless otherwise specified)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(on)\_0,1\_LED}$ (1)	Turn-on delay time at T_j = 25 °C	R_L = 22.8 Ω	10	65	120	µs
$t_{d(off)\_0,1\_LED}$ (1)	Turn-off delay time at T_j = 25 °C	R_L = 22.8 Ω	10	40	100	µs
$(dV_{OUT}/dt)_{on\_0,1\_LED}$ (1)	Turn-on voltage slope at T_j = 25 °C	R_L = 22.8 Ω	0.2	0.5	0.8	V/µs
$(dV_{OUT}/dt)_{off\_0,1\_LED}$ (1)	Turn-off voltage slope at T_j = 25 °C	R_L = 22.8 Ω	0.1	0.5	0.7	V/µs
$W_{ON\_0,1\_LED}$	Switching energy losses at turn-on (t_{won})	R_L = 22.8 Ω	—	0.04	0.1 (2)	mJ
$W_{OFF\_0,1\_LED}$	Switching energy losses at turn-off (t_{woff})	R_L = 22.8 Ω	—	0.045	0.11 (2)	mJ
$t_{SKEW\_0,1\_LED}$ (1)	Differential Pulse skew (t_{PHL} - t_{PLH})	R_L = 22.8 Ω	-75	-25	25	µs

1. See *Figure 35: Switching times and Pulse skew*.
2. Parameter guaranteed by design and characterization, not subject to production test.

Table 13. Power section in LED Mode (7 V < V_{CC} < 28 V; -40 °C < T_j < 150 °C, unless otherwise specified)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$R_{ON\_0,1\_LED}$	On-state resistance in LED Mode Ch0 and Ch1	I_{OUT} = 0.57 A; T_j = 25°C		140		mΩ
		I_{OUT} = 0.57 A; T_j = 150°C			280	
		I_{OUT} = 0.57 A; V_{CC} = 5 V; T_j = 25°C			210	
$I_{LIMH\_0,1\_LED}$(1)	DC short circuit current in Bulb Mode Ch0 and Ch1	V_{CC} = 13 V	5.5	8	11	A
		4 V < V_{CC} < 18 V(2)				
$I_{LIML\_0,1\_LED}$	Short circuit current during thermal cycling in Bulb Mode Ch0 and Ch1	V_{CC} = 13 V; T_R < T_j < T_{TSD}		2		
$V_{ON\_0,1\_LED}$	Output voltage drop limitation in LED Mode Ch0 and Ch1	I_{OUT} = 0.07 A		20		mV

1. Parameter guaranteed by an indirect test sequence.
2. Parameter guaranteed by design and characterization; not subject to production test.

Table 14. MultiSense in LED Mode (7 V < V_{CC} < 18 V; -40 °C < T_j < 150 °C)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
K_{OL}	I_{OUT}/I_{SENSE}	I_{OUT} = 0.01 A; V_{SENSE} = 0.5 V; V_{SEn} = 5 V	120			
dK_{cal}/K_{cal}(1)(2)	Current sense ratio drift at calibration point	I_{cal} = 17.5 mA; I_{OUT} = 10 mA to 25 mA; V_{SENSE} = 0.5 V; V_{SEn} = 5 V	-30		30	%
K_{LED}	I_{OUT}/I_{SENSE}	I_{OUT} = 0.025 A; V_{SENSE} = 0.5 V; V_{SEn} = 5 V	150	380	610	
dK_{LED}/K_{LED}(1)(2)	Current sense ratio drift	I_{OUT} = 0.025 A; V_{SENSE} = 0.5 V; V_{SEn} = 5 V	-25		25	%
$K_{0\_CH0,1\_L}$	I_{OUT}/I_{SENSE}	I_{OUT} = 0.15 A; V_{SENSE} = 4 V; V_{SEn} = 5 V	240	405	570	
dK_0/K_0(1)(2)	Current sense ratio drift	I_{OUT} = 0.15 A; V_{SENSE} = 4 V; V_{SEn} = 5 V	-15		15	%
$K_{1\_CH0,1\_L}$	I_{OUT}/I_{SENSE}	I_{OUT} = 0.7 A; V_{SENSE} = 4 V; V_{SEn} = 5 V	300	380	460	
dK_1/K_1(1)(2)	Current sense ratio drift	I_{OUT} = 0.7 A; V_{SENSE} = 4 V; V_{SEn} = 5 V	-8		8	%
MultiSense timings (Current Sense mode - see *Figure 36*)						
$t_{DSENSE1H}$	Current sense settling time from rising edge of SEn	V_{IN} = 5 V; V_{SEn} = 0 V to 5 V; R_{SENSE} = 1 kΩ; R_L = 22.8 Ω			60	µs