40V, 100mΩ Single-Channel Smart High-Side Power Switch

General Description

The ETQ2H10011 device is a single channel, fully-protected, high-side power switch with an integrated NMOS power FET and charge pump. Full diagnostics and high-accuracy current-sense features enable intelligent control of the load. A programmable current limit function greatly improves the reliability of the whole system. The device diagnostic reporting has two versions to support both digital status and analog current-sense output, both of which can be set to the high impedance state when diagnostics are disabled, for multiplexing the MCU analog or digital interface among devices.

For version A, the digital status report is implemented with an open-drain structure. When a fault condition occurs, it pulls down to GND. A 3.3V or 5V external pull up is required to match the micro controller supply level.

For version B, high accuracy current sensing allows a better real time monitoring effect and more accurate diagnostics without further calibration. A current mirror is used to source 1/K of the load current, which is reflected as voltage on the CS pin. K is a constant value across the temperature and supply voltage. The current sensing function operates normally within a wide linear region from 0 to 4V. The CS pin can also report a fault by pulling up the voltage of V_{CS_H}.

The external high accuracy current limit allows setting the current limit value by application. It highly improves the reliability of the system by clamping the inrush current effectively under start up or short circuit conditions. Also, it can save system costs by reducing PCB trace, connector size, and the preceding power stage capacity. An internal current limit is also implemented in this device. The lower value of the external or internal current limit value is applied. An active drain and source voltage clamp is built in to address switching off the energy of inductive loads, such as relays, solenoids, pumps, motors, and so forth. During the inductive switching-off cycle, both the energy of the power supply (EBAT) and the load (ELOAD) are dissipated on the high-side power switch itself. With the benefits of process technology and excellent IC layout, the ETQ2H10011 device can achieve excellent power dissipation capacity, which can help save the external free wheeling circuitry in most cases.

The ETQ2H10011 device can be used as a high-side power switch for a wide variety of resistive, inductive, and capacitive loads, including the low-wattage bulbs, LEDs, relays, solenoids, and heaters.

ETQ2H10011 is offered in a HTSSOP14 (4.4mm ×5.0mm) package.

Features

- Wide voltage operation: 3.5V to 40V
- Very low standby current: <0.5 μA
- Input control: 3.3V and 5V logic compatible
- High-accuracy current sense

  ±80%@5mA

  ±40%@20mA

  ±20%@40mA

  ±10%@100mA

  ±5%@>1A
- Programmable current limit with external resistor: ±25% at 0.5A
- Diagnostic enable function for multiplexing of MCU analog or digital interface
- Overload and short-circuit protection
- Inductive load negative voltage clamp
- Under voltage lockout (UVLO) protection
- Thermal shutdown/swing with self recovery
- Loss of supply protection
- Reverse battery protection with external circuitry
- On- and Off-state output open- and short-to battery detection
- Overload and short to ground detection and current limit
- Thermal shutdown/swing detection with self recovery
- AEC-Q100 qualified with the following results:

  -- Device temperature grade 1: -40°C to +125°C ambient operating temperature range

  -- Device HBM ESD classification ±2KV Pass

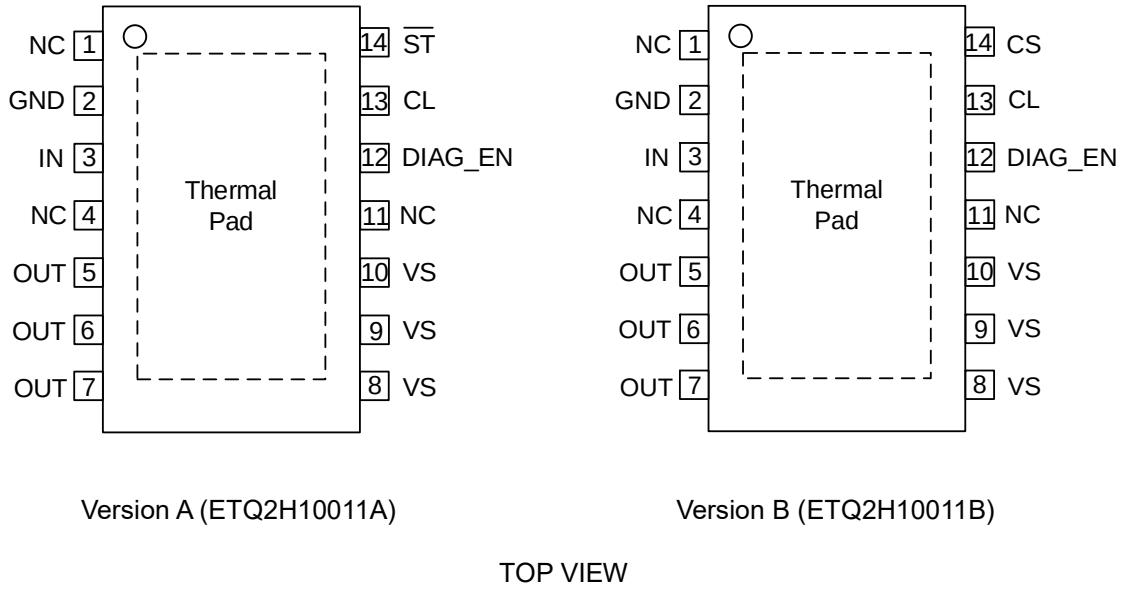
  -- Device CDM ESD classification level ±1KV Pass
- HTSSOP14 thermally-enhanced package

Part No.	Package	MSL
ETQ2H10011	HTSSOP14 (4.4mm × 5.0mm)	Level 3

Application

- High-side power switch for sub-module
- Power switch for low-wattage lamp
- High-side relays and solenoids
- PLC Digital output power switch
- General resistive, inductive, and capacitive loads

Pin Configuration



Version A (ETQ2H10011A) Version B (ETQ2H10011B)

TOP VIEW

Figure 1. Pin Configuration

Pin Function

Pin No.	Pin Name	I/O	Description
1,4,11	NC	-	No-connect pin, leave floating.
2	GND	-	Ground pin.
3	IN	I	Input control for channel activation.
5,6,7	OUT	O	Output, connected to load (NMOS source).
8,9,10	VS	I	Power supply; battery voltage.
12	DIAG_EN	I	Enable and disable pin for diagnostic functions. Connect to device GND if not used.
13	CL	I	Programmable current-limit pin. Connect to device GND if external current limit is not used.
14(verA)	ST	O	Open-drain diagnostic status output. Leave floating if not used.
14(verB)	CS	O	Current-sense output. Leave floating if not used.
-	Thermal pad	-	Thermal pad. Connect to device GND or leave floating.

Block Diagram

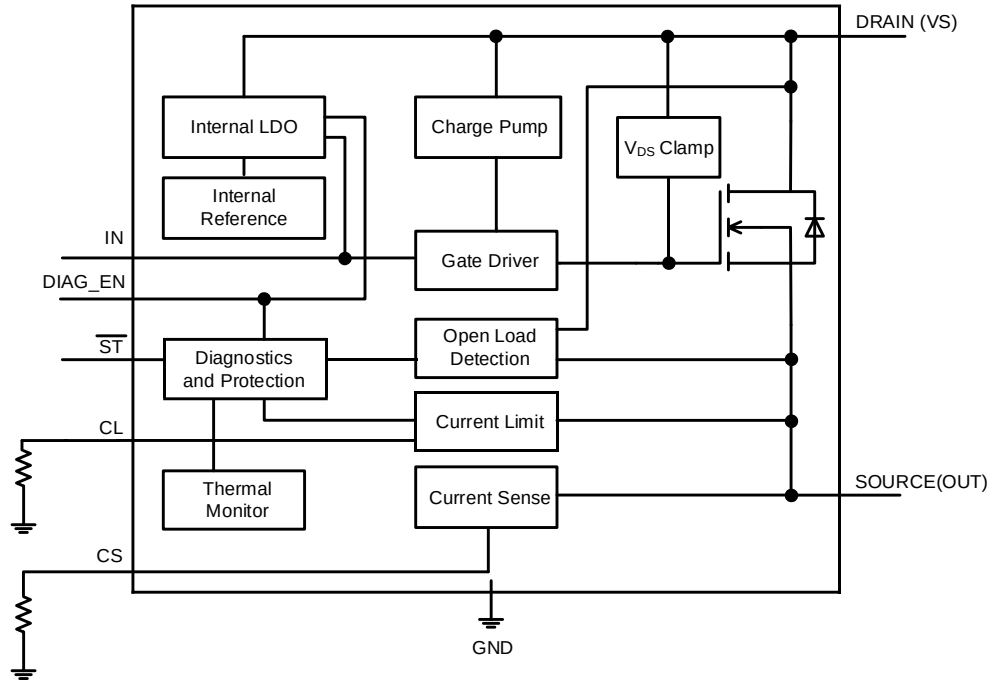


Figure 2. Block Diagram

Absolute Maximum Ratings(1)(2)(3)

Parameters	Min	Max	Unit
Supply voltage(4), t < 400 ms		48	V
Reverse polarity voltage(5)	-18		V
Continuous drain current	Internally limited		A
Reverse current on GND	-50	20	mA
Reverse current on GND, t < 120 s	-250	20	mA
Voltage on IN/DIAG_EN pin	-0.3	7	V
Current on IN /DIAG_EN pin	-30	2	mA
Voltage on $\overline{ST}$ pin	-0.3	7	V
Current on $\overline{ST}$ pin	-30	10	mA
IN pin PWM frequency	-0.3	7	V
Voltage on CL pin	-0.3	7	V
Current on CL pin	-2	30	mA
Voltage on CS pin	-0.3	6.5	V
Current on CS pin	-2	30	mA
Inductive load switch-off energy dissipation, single pulse(6)		70	mJ
Operating junction temperature,T_J	-40	150	°C
Storage temperature,T_{STG}	-65	150	°C

Note1: Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under Recommended Operating Conditions. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

Note2: All voltage values are with respect to GND.

Note3: Absolute negative voltage on these terminals is not to go below -0.3V.

Note4: Absolute maximum voltage, withstand 48V load dump voltage for 400ms.

Note5: Reverse polarity condition: t < 60s, reverse current < Irev1, GND pin 1kΩ resistor in parallel with diode.

Note6: Test condition: V_S = 40V, L = 50mH, R = 50Ω, T_J = 150°C. FR4 2s2p board, 2 × 70μm Cu, 2 × 35μm Cu. 600mm^2 thermal pad copper area.

Recommended Operating Conditions

The Recommended Operating Conditions table defines the conditions for actual device operation. Recommended operating conditions are specified to ensure optimal performance to the datasheet specifications. ETEK does not recommend exceeding them or designing to Absolute Maximum Ratings.

Symbol	Parameters	Min	Max	Unit
V_S	Operating voltage	5	40	V
V_{EN}	Voltage on IN/DIAG_EN pin	0	5	V
V_{ST}	Voltage on ST pin	0	5	V
I_{O_NOM}	Nominal DC load current	0	4	A
T_A	Operating ambient temperature range	-40	125	°C
T_J	Operating junction temperature range	-40	150	°C

Electrical Characteristics

5 V < V_S < 40 V; –40°C < T_J < 150°C unless otherwise specified.

Symbol	Parameters	Conditions	Min	Typ	Max	Unit
OPERATING VOLTAGE						
V_{S_NOM}	Nominal operating voltage		5		40	V
V_{S_OP}	Extended operating voltage	R_{DS_ON} value increases maximum 20%, compared to 5 V, see R_{DS_ON} parameter	3.5		5	V
V_{S_UVR}	Under-voltage restart	V_S rises up, V_S > V_{S_UVR}, device turn on	3.4	3.7	4	V
V_{S_UVF}	Under-voltage shutdown	V_S falls down, V_S < V_{S_UVF}, device shuts off	2.9	3.2	3.5	V
V_{UV_HYS}	Under-voltage shutdown, hysteresis			0.5		V

Electrical Characteristics (Continued)

5 V < V_S < 40 V; –40°C < T_J < 150°C unless otherwise specified.

Symbol	Parameters	Conditions	Min	Typ	Max	Unit
OPERATING CURRENT						
I_{NOM}	Nominal operating current	V_S = 13.5 V, V_{IN} = 5 V, V_{DIAG_EN} = 0 V, no load		2.2	5	mA
		V_S = 13.5 V, V_{IN} = 5 V, V_{DIAG_EN} = 0 V, 10Ω load		6	10	mA
I_{OFF}	Standby current	V_S = 13.5 V, V_{IN} = V_{DIAG_EN} = V_{CS} = V_{CL} = 0 V V_{OUTPUT} = 0 V, T_A = 25°C		0.1	0.5	uA
		V_S = 13.5 V, V_{IN} = V_{DIAG_EN} = V_{CS} = V_{CL} = 0 V V_{OUTPUT} = 0 V, T_A = 125°C		1	5	µA
I_{OFF_DIAG}	Standby current with diagnostic enabled	V_S = 13.5 V, V_{IN} = 0 V, V_{DIAG_EN} = 5 V		1	1.6	mA
t_{OFF_DEG}	Standby mode deglitch time(7)	IN from high to low, if deglitch time > t_{OFF_DEG}, enters into standby mode.		2		ms
I_{LEAK_OUT}	Off-state output leakage current	V_S = 13.5 V, V_{IN} = V_{OUTPUT} = 0 V, T_A = 25°C		0.1	0.5	µA
		V_S = 13.5 V, V_{IN} = V_{OUTPUT} = 0 V, T_A = 125°C		1	5	µA
T_{SD}	Thermal shutdown(7)			175		°C
	Thermal shutdown hysteresis(7)			20		
T_{SW}	Thermal swing shutdown threshold			60		
T_{HYS}	Hysteresis for resetting the thermal shutdown and swing			10		
POWER STAGE						
R_{DS_ON}	On-state resistance	V_S > 5 V, T_A = 25°C		90	120	mΩ
		V_S > 5 V, T_A = 125°C		140	170	mΩ
		V_S = 3.5 V, T_A = 25°C		95	120	mΩ
I_{LIM_NOM}	Internal current limit		7	10	13	A
I_{LIM_TSD}	Current limit during thermal shutdown	Internal current limit, thermal cycling condition		5		A
		External current limit, thermal cycling condition; Percentage of current limit set		50%		A

Electrical Characteristics (Continued)

5 V < V_S < 40 V; –40°C < T_J < 150°C unless otherwise specified.

Symbol	Parameters	Conditions	Min	Typ	Max	Unit
V_{DS}	Clamp drain-to-source voltage internally clamped	VS=40V	40		70	V
OUTPUT DIODE CHARACTERISTICS						
V_F	Drain-to-source diode voltage	V_{IN} = 0, I_{OUT} = -0.2 A		0.7	1	V
I_{REV1}	Continuous reverse current when reverse polarity(8)	t < 60 s, V_S = 13.5 V, GND pin 1kΩ resistor in parallel with diode. T_A = 25°C. See I_{REV1} test condition.		4		A
I_{REV2}	Continuous reverse current when V_{OUT} > V_S + Vdiode(8)	t < 60 s, V_S = 13.5 V. T_A = 25°C. See I_{REV2} test condition.		2		A
LOGIC INPUT (IN AND DIAG_EN)						
V_{IH}	Input or DIAG_EN high-level voltage		2			V
V_{IL}	Input or DIAG_EN low-level voltage				0.8	V
V_{I_HYS}	Input or DIAG_EN hysteresis voltage			250		mV
R_{PD_EN}	Input pull down resistor		200	500	800	kΩ
R_{PD_DIAG}	Diag pull down resistor		40	150	350	kΩ
DIAGNOSTICS						
V_{OL_OFF}	Open-load detection threshold in off state	V_{IN} = 0 V, When V_S - V_{OUT} < V_{OL_OFF}, duration longer than T_{OL_OFF}, Open load detected.	1.4	1.8	2.6	V
I_{OL_OFF}	Off-state output sink current with open load	V_{IN} = 0 V, V_S = V_{OUT} = 13.5 V, T_A = 125°C.		-20	-50	µA
t_{OL_OFF}	Open-load detection-threshold deglitch time in off state	V_{IN} = 0 V, When V_S - V_{OUT} < V_{OL_OFF}, duration longer than t_{OL_OFF}. Open load detected.		600	1000	µs

Electrical Characteristics (Continued)

5 V < V_S < 40 V; –40°C < T_J < 150°C unless otherwise specified.

Symbol	Parameters	Conditions	Min	Typ	Max	Unit
I_{OL_ON}	Open-load detection threshold in on state	V_{IN} = 5 V, when I_{OUT} < I_{OL_ON}, duration longer than T_{OL_ON}. Open load detected. Version A only	2	6	10	mA
t_{OL_ON}	Open-load detection-threshold deglitch time in on-state	V_{IN} = 5 V, when I_{OUT} < I_{OL_ON}, duration longer than t_{OL_ON}. Open load detected. Version A only		700		µs
V_{ST}	Status low output voltage	I_{ST} = 2 mA Version A only			0.4	V
CURRENT SENSE (VERSION B) AND CURRENT LIMIT						
K	Current sense current ratio			500		
K_{CL}				2000		
dK/K	Current-sense Accuracy	I_{LOAD} ≥ 5 mA	-80		80	%
		I_{LOAD} ≥ 20 mA	-40		40	%
		I_{LOAD} ≥ 40mA	-20		20	%
		I_{LOAD} ≥0.1 A	-10		10	%
		I_{LOAD} ≥ 1A	-5		5	%
dK_{CL}/K_{CL}	External current-limit accuracy[9][10]	I_{LIMIT} ≥ 0.5 A	-25		25	%
V_{CS_LIN}	Linear current sense voltage range[7]	V_S ≥ 5 V	0		4	V
I_{OUT_LIN}	Linear output current range[7]	V_S ≥ 5 V, V_{CS_LIN} ≤ 4 V	0		4	A
V_{CS_H}	Current-sense fault high voltage	V_S ≥ 7 V	4.3	4.75	4.9	V
		V_S ≥ 5 V	Min (V_S -0.8, 4.3)	4.75	4.9	V
I_{CS_H}	Current sense fault condition current	V_{CS} = 4.3 V, V_S > 7 V	10			mA
V_{CL_TH}	Current limit internal threshold voltage[7]		1.05	1.233	1.35	V
I_{CS_LEAK}	Current sense leakage current in disabled mode	V_{IN} = 5 V, R_{LOAD} = 10 Ω, V_{DIAG_EN} = 0 V, T_A =125°C		0.1	1	µA
		V_{IN} = 0 V, V_{DIAG_EN} = 0 V, T_A = 125°C		0.1	1	µA

Electrical Characteristics (Continued)

5 V < V_S < 40 V; –40°C < T_J < 150°C unless otherwise specified.

Symbol	Parameters	Conditions	Min	Typ	Max	Unit
Timing Requirements – Current Sense Characteristics						
t_{CS_OFF1}	CS settling time from DIAG disabled	V_{IN} = 5 V, I_{LOAD} ≥ 5 mA. V_{DIAG_EN} from 5 to 0 V. CS to 10% of sense value.		0.2	10	µs
t_{CS_ON1}	CS settling time from DIAG enabled	V_{IN} = 5 V, I_{LOAD} ≥ 5 mA. V_{DIAG_EN} from 0 to 5 V. CS to 90% of sense value.		2	10	µs
t_{CS_OFF2}	CS settling time from IN falling edge	V_{DIAG_EN} = 5 V, I_{LOAD} ≥ 5 mA. IN from 5 to 0 V. CS to 10% of sense value.		0.2	10	µs
		V_{DIAG_EN} = 5 V, I_{LOAD} ≥ 5 mA. IN from 5 to 0 V. Current limit triggered.		150	250	µs
t_{CS_ON2}	CS settling time from IN rising edge	V_{VS} = 13.5 V, V_{DIAG_EN} = 5 V, I_{LOAD} ≥ 100 mA. V_{IN} from 0 to 5 V. CS to 90% of sense value.		100	180	µs

Switching Characteristics

V_S = 13.5V, R_{LOAD} = 10Ω, over operating free-air temperature range

Symbol	Parameters	Conditions	Min	Typ	Max	Unit
t_{ON}	Turn-on delay time	IN rising edge to V_{OUT} = 10%, DIAG_EN high		35	70	µs
t_{OFF}	Turn-off delay time	IN falling edge to V_{OUT} = 90%, DIAG_EN high		25	60	µs
dV/dt_{ON}	Slew rate on	V_{OUT} = 10% to 90%, DIAG_EN high	0.1	0.35	2	V/µs
dV/dt_{OFF}	Slew rate off	V_{OUT} = 90% to 10%, DIAG_EN high	0.1	0.55	2	V/µs
	Slew rate on and off matching			0.2		V/µs

Note7: Value is specified by design, not subject to production test.

Note8: Value is based on the minimum value of the 10 pcs/3 lots samples.

Note9: External current-limit accuracy is only applicable to overload conditions greater than 1.5× the current-limit setting.

Note10: External current-limit setting is recommended to be higher than 500 mA.

Sequence Diagram and Waveform

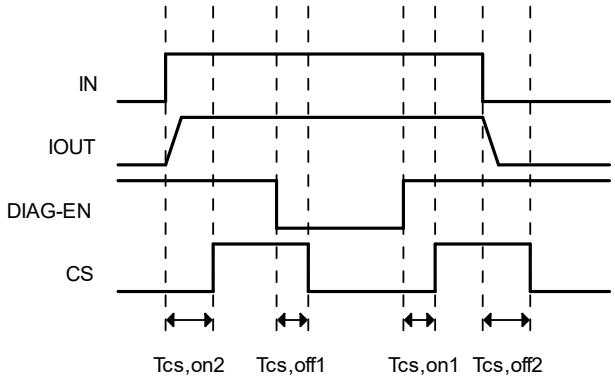


Figure 3. CS Delay Characteristics

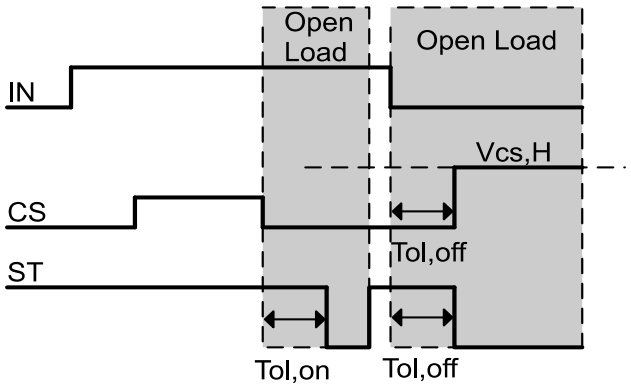


Figure 4. Open-Load Blanking Time Characteristics

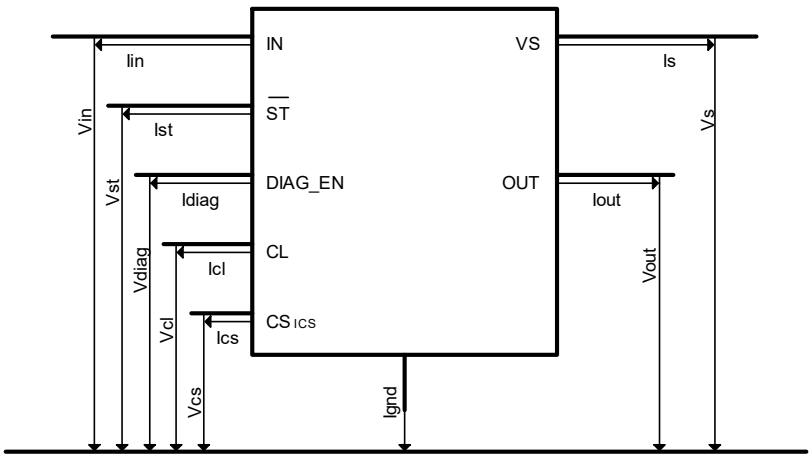


Figure 5. Pin Current and Voltage Conventions

Sequence Diagram and Waveform (Continued)

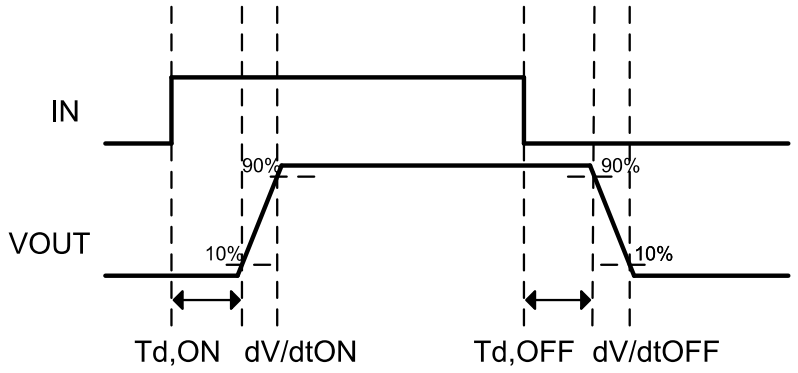


Figure 6. Switching Characteristics Diagram

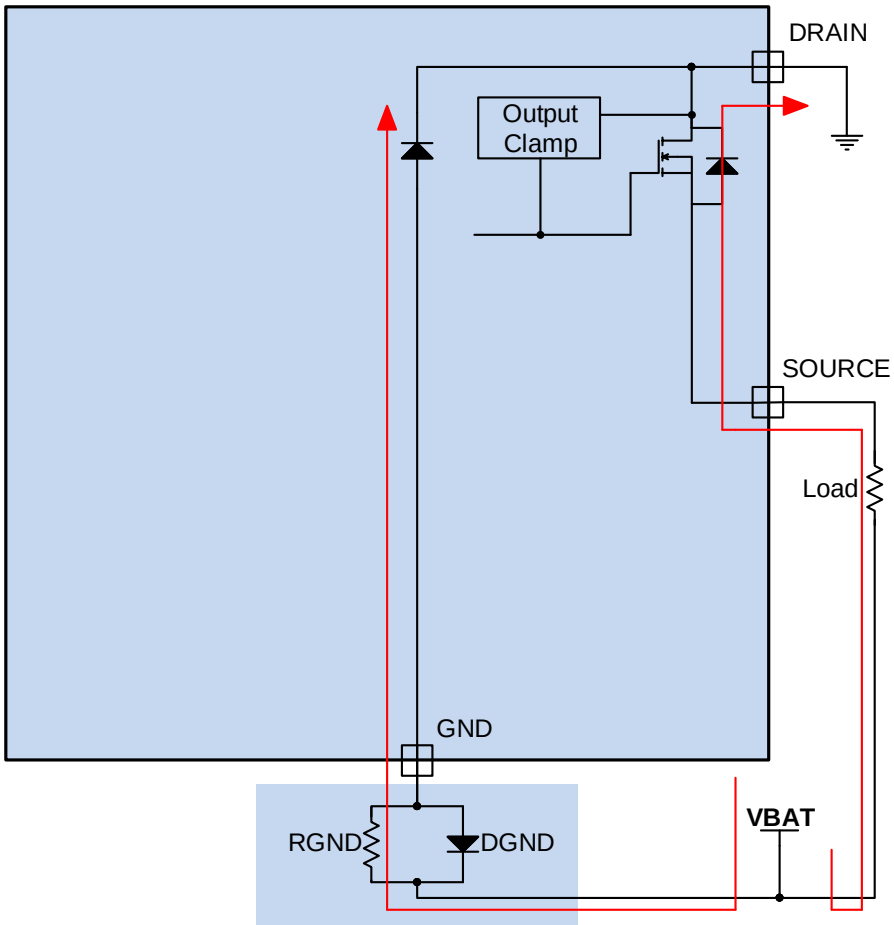


Figure 7. I_{REV1} Test Condition

Sequence Diagram and Waveform (Continued)

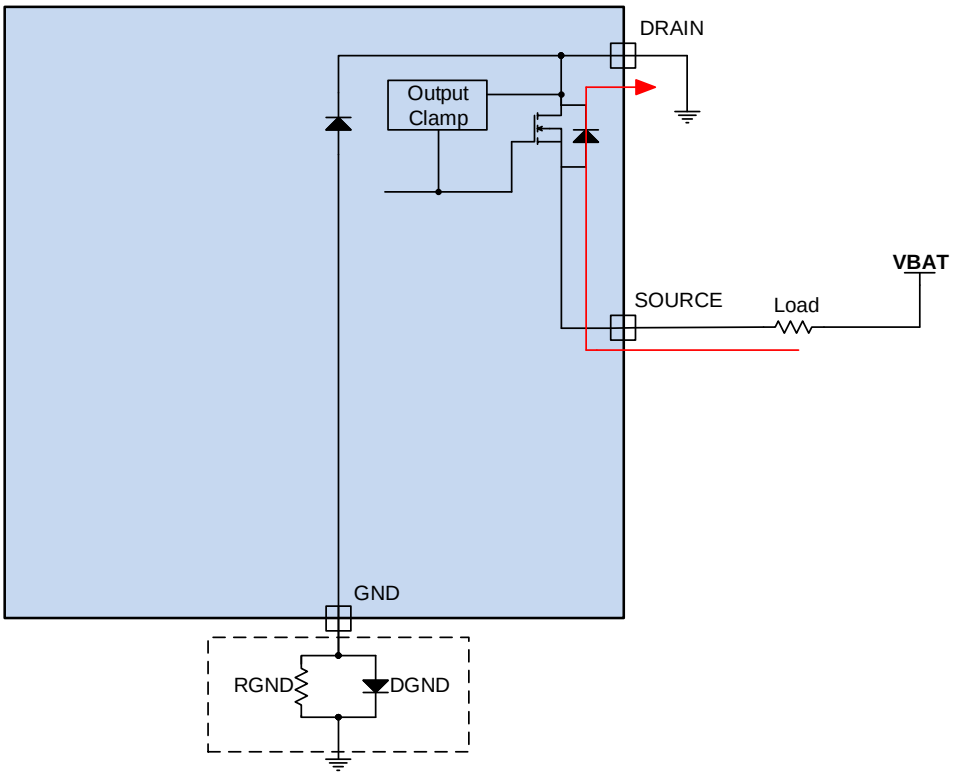


Figure 8. I_{REV2} Test Condition

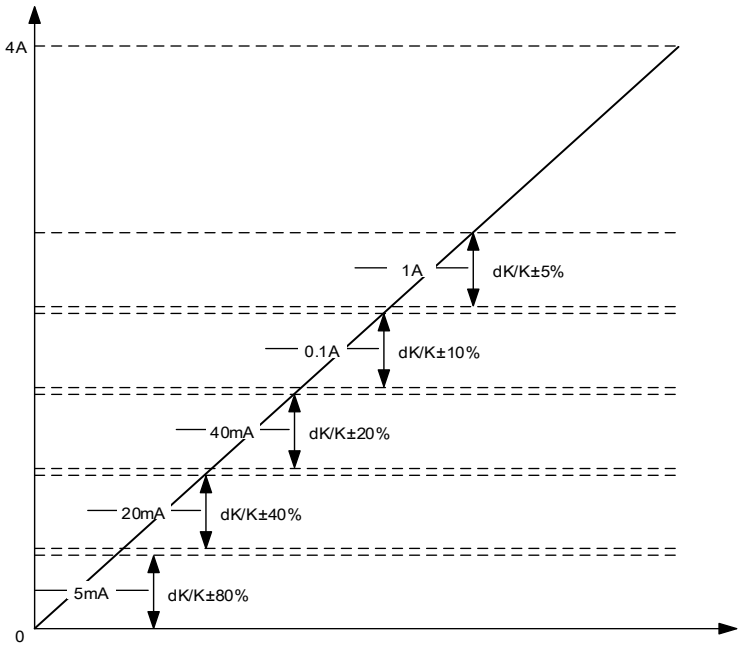


Figure 9. Current-Sense Accuracy

Application Circuits

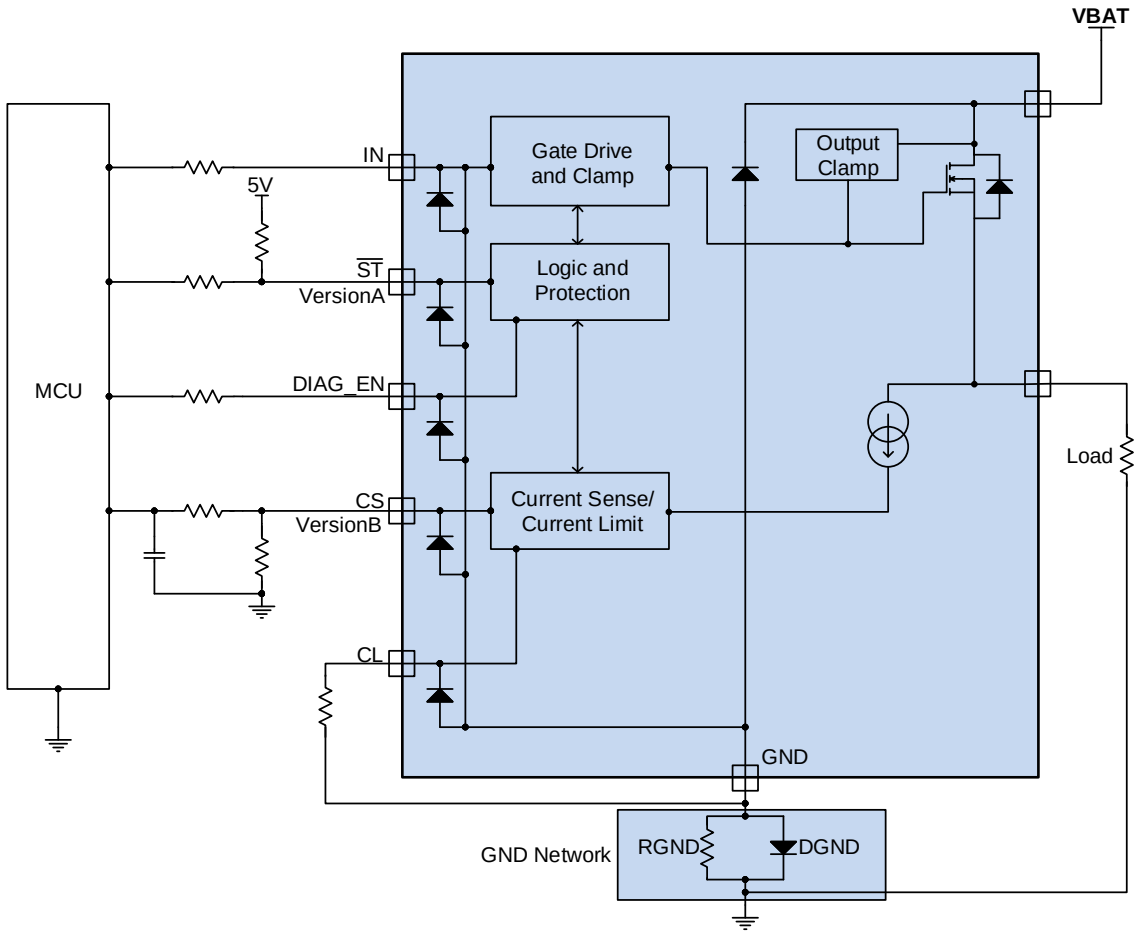
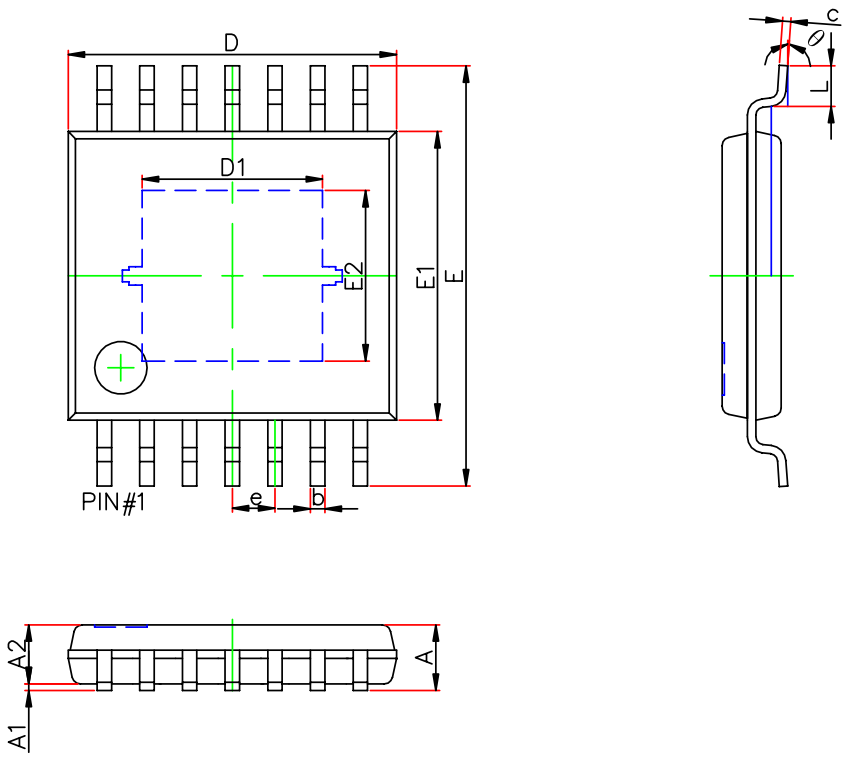


Figure 10. Reference Application Circuit

Package Dimension

HTSSOP14

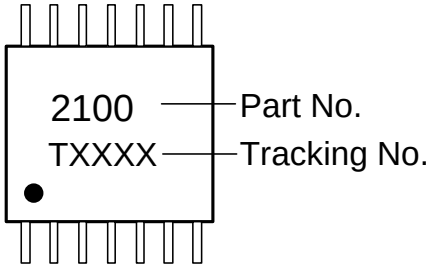


COMMON DIMENSIONS
(UNITS OF MEASURE=MILLIMETER)

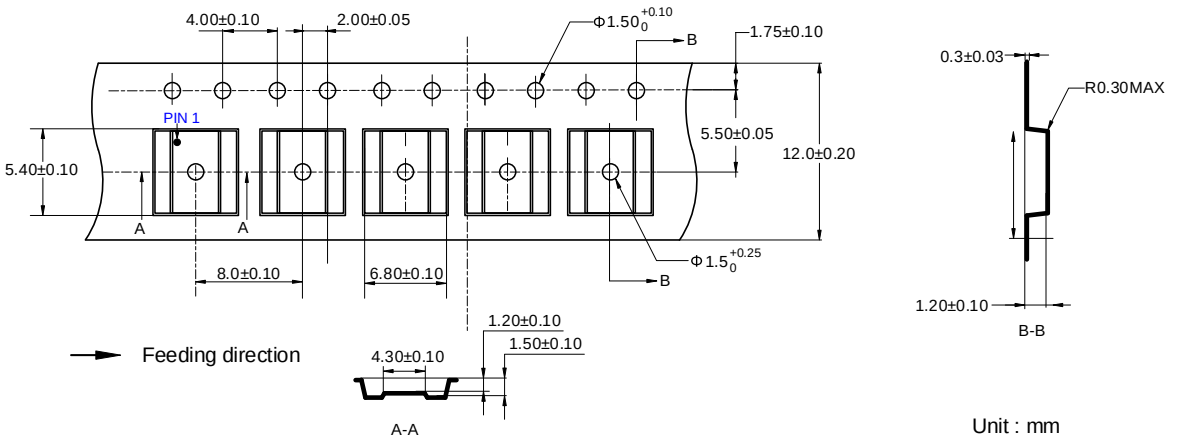
SYMBOL	Dimensions in Millimeters		
	MIN	NOM	MAX
A	—	—	1.200
A1	0.050	0.100	0.150
A2	0.800	0.900	1.000
b	0.190	0.245	0.300
c	0.090	0.145	0.200
D	4.900	5.000	5.100
D1	2.650	2.750	2.850
E	6.250	6.400	6.550
E1	4.300	4.400	4.500
E2	2.550	2.650	2.750
e	0.650(BSC)		
L	0.500	0.600	0.700
θ	1°	4°	7°

Unit: mm

Marking



Tape Information



Revision History and Checking Table

Version	Date	Revision Item	Modifier	Function & Spec Checking	Package & Tape Checking
1.0	2026.5.26	Initial Version	Zoucm	Guoy	Shib