

CAT2300

Current Mirror and Switch Controller for SENSEFET[®] MOSFETs

Description

CAT2300 is a controller for SENSEFET[®] MOSFET current monitoring in high-side switch applications.

CAT2300 provides current mirroring and ON/OFF control for SENSEFET MOSFETs. Exact control and matching of the Sense output of the SENSEFET with the Kelvin voltage insures accurate current monitoring over many decades of current.

Designed for use with NTMFS4833NST1G, NTMFS4854NST1G or similar SENSEFET MOSFETs from ON Semiconductor, CAT2300 is the single chip alternative to discrete circuits for monitoring and controlling 0.9 V – 1.5 V power busses. When teamed with a SENSEFET, CAT2300 will track currents up to 25 A and resolve currents below 100 mA.

CAT2300 provides logic level ON/OFF control of the power MOSFET and its own internal circuitry, reducing power consumption to virtually zero milliwatts.

Packaged in a space saving low profile 2 x 3 mm TDFN, CAT2300 operates over the full industrial temperature range of -40°C to +85°C.

Features

- Precision Current Measurement of 0.9 V – 1.5 V Power Supply Rails
- ON/OFF Power FET Control with Soft-start
- Sense Current Mirroring to 70 mA (equal to 25 A flowing in the power bus)
- User Adjustable Current to Voltage Conversion Ratio
- 150 μ V Typical Matching between Kelvin and Sense Leads
- Less than 1 μ A Current Consumption in Shutdown Mode
- This Device is Pb-Free, Halogen Free/BFR Free and RoHS Compliant

Typical Applications

- Portable Computers
- Backplane Bus Control
- Power Distribution

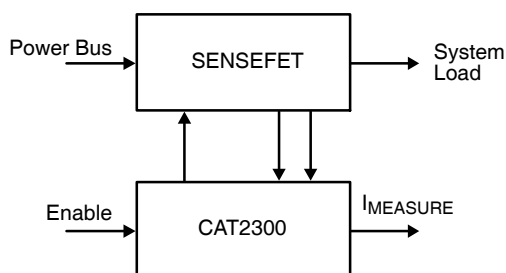


Figure 1. System Application



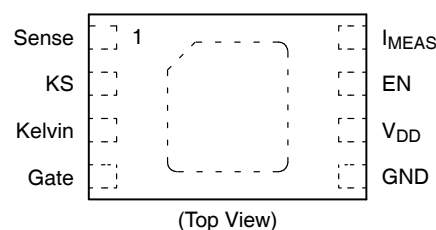
ON Semiconductor[®]

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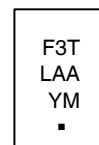


TDFN-8
VP2 SUFFIX
CASE 511AK

PIN CONFIGURATION



MARKING DIAGRAM



- F3T = Specific Device Code
- L = Assembly Location Code
- AA = Assembly Lot Number (Last Two Digits)
- Y = Production Year (Last Digit)
- M = Production Month (1-9, O, N, D)
- = Pb-Free Microdot

ORDERING INFORMATION

Device	Package	Marking	Shipping [†]
CAT2300	TDFN	F3T	3,000 / Tape & Reel

[†]For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specification Brochure, BRD8011/D.

ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 7 of this data sheet.

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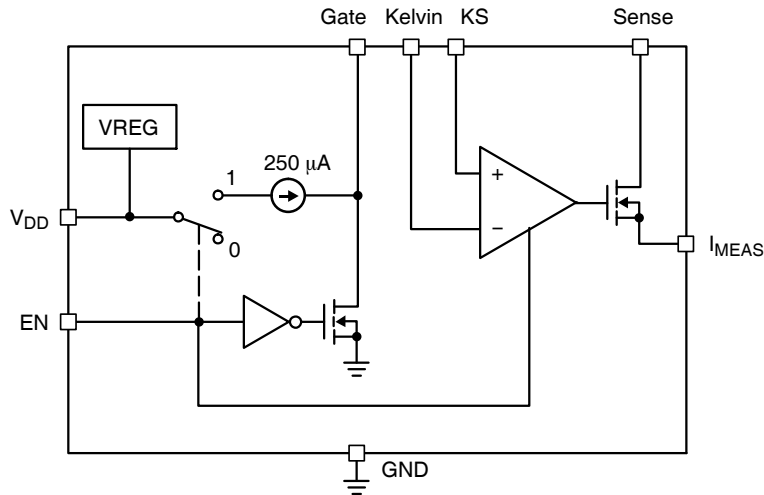


Figure 2. Simplified Block Diagram

Table 1. PIN FUNCTION DESCRIPTION

Pin No.	Pin Name	Function
1	Sense	Connects to Sense pin of SENSEFET and directs sensed current to I _{MEAS} output.
2	KS	Kelvin Sense; a Kelvin connection for the current mirror control amplifier. This connection must be made directly to Sense on the SENSEFET package. Do not share any trace length with CAT2300's Sense lead.
3	Kelvin	Connects to Kelvin pin of the SENSEFET. Serves as the reference point for Sense lead biasing.
4	Gate	Connects to Gate of the SENSEFET and controls SENSEFET operation.
5	GND	Electrical ground for IC.
6	V _{DD}	External voltage supply for driving the gate of the SENSEFET and power supply for CAT2300 internal circuitry via an internal voltage regulator.
7	EN	Enable: High true logic input. Turns ON SENSEFET and CAT2300's internal circuitry. A logic LOW on EN grounds Gate, shutting off the SENSEFET and shuts down the internal current source and mirroring circuitry.
8	I _{MEAS}	Sensed current output. A resistor between I _{MEAS} and ground develops a voltage proportional to the current flowing through the SENSEFET.
PAD		Backside paddle is internally connected to GND. This pad may be left floating but if connected with PCB it must be to the ground plane of circuitry which is also grounded.

Table 2. ABSOLUTE MAXIMUM RATINGS (Note 1)

Parameter	Symbol	Value	Unit
V _{DD}	V _{DD}	6.5	V
Gate		±15	mA
V _K , EN, Sense, KS, Kelvin, I _{MEAS}		6.5	V
Junction Temperature		150	°C

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

1. Guaranteed by design.

Table 3. RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	Value	Unit
V _K	V _K	0.9 to 1.5	V
V _{DD}	V _{DD}	5	V
Maximum Junction Temperature	T _{JUNCTION}	125	°C
Ambient Temperature Range	T _{AMBIENT}	-40 to +85	°C

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Table 4. PACKAGE THERMAL PERFORMANCE

Package	Symbol	Test Conditions	Min	Typ	Max	Unit
TDFN-8	θ_{JA}	1 oz Copper Thickness, 100 mm ²		160		°C/W
	θ_{JC}			35		
SOIC-8	θ_{JA}	1 oz Copper Thickness, 100 mm ²		160		°C/W
	θ_{JC}			25		

Table 5. DC ELECTRICAL CHARACTERISTICS

($V_K = 0.9 - 1.5$ V; $V_{DD} = +5$ V; $T_{AMBIENT} = -40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$, $T_{JUNCTION} = -40^{\circ}\text{C}$ to $+125^{\circ}\text{C}$, unless otherwise specified.)

Parameter	Symbol	Test Conditions	Limits			Units
			Min	Typ	Max	
Kelvin voltage	V_K		0.9		1.5	V
Gate Drive input voltage	V_{DD}		4.5		5.5	V
Supply Current on V_{DD} pin	I_{VDD}	EN = logic 0			1	μA
		EN = logic 1	65	77	100	μA
Gate drive Sourcing	I_{GATE}	$V_{GATE} = V_{DD} - 1$ V	-235	-280	-330	μA
Gate drive Sinking		$V_{GATE} = 0.6$ V	7	9.6	13	mA
Offset Voltage	V_{OS}	$V_{OS} = V_{KELVIN} - V_{SENSE}$ $V_K = 0.9$ V to 1.5 V		± 150	± 300	μV
Input Bias Current; Kelvin and KS inputs	I_K			100	150	nA
Power Supply Rejection Ratio	PSRR			70		db
I_{MEAS} output current	I_{MEAS}		0		70	mA
Output voltage of I_{MEAS} amplifier	V_{O_IM}		0		$V_K - 0.1$	V

LOGIC

Low level input voltage	V_{IL}	EN	0.9	1.1	1.26	V
High level input voltage	V_{IH}	EN	1.4	1.65	1.9	V
Hysteresis				0.55		V
Low level input current	I_{IL}	EN, $V_{DD} = 0$ V or 5.5 V			2	μA
High level input current	I_{IH}	EN, $V_{DD} = 0$ V or 5.5 V			2	μA

Table 6. AC OPERATING CHARACTERISTICS

($V_K = 0.9$ V - 1.5 V; $V_{DD} = 5$ V; $T_{AMBIENT} = -40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$, $T_{JUNCTION} = -40^{\circ}\text{C}$ to $+125^{\circ}\text{C}$, unless otherwise specified.)

Parameter	Symbol	Test Conditions	Limits			Units
			Min	Typ	Max	
I_{MEAS} output rise time	t_R	20 Ω , 100 pF, $V_K = 1.5$ V $I_{SENSE} : 2$ mA - 70 mA		38		μs
I_{MEAS} output fall time	t_F			33		μs
I_{MEAS} Settling time	t_S	EN = Logic 0 \rightarrow 1, $I_{SENSE} = 1$ mA		30		μs
		EN = Logic 0 \rightarrow 1, $I_{SENSE} = 70$ mA		50		μs

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TYPICAL PERFORMANCE CHARACTERISTICS

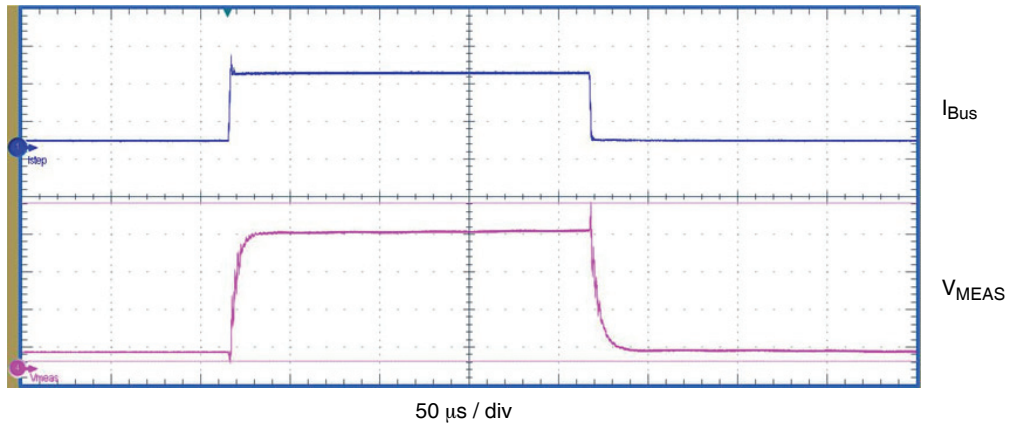


Figure 3. Load Step: 1 A – 10 A

PIN DESCRIPTION

Sense

Sense connects directly to the SENSEFET's Sense pin and directs the sensed current to the I_{MEAS} output. Sense is controlled by an amplifier with a FET follower stage to maintain Sense at exactly the Kelvin voltage, thus insuring accuracy of the SENSEFET's mirror current.

KS

KS = Kelvin Sense; a Kelvin connection for the mirroring amplifier. Current measurement accuracy is dependent upon the voltage match between the SENSEFET's Sense and Kelvin leads. To minimize voltage losses in the PCB trace between CAT2300 and the SENSEFET, a Kelvin connection for the control amplifier is provided. **KS must be a dedicated connection, shared by no other circuitry, and tied directly to the Sense pin on of the SENSEFET.**

Careful layout is critical in achieving full SENSEFET performance. PCB trace resistance can no longer be ignored as it can be in typical low current circuit designs. Microvolt offsets (μV) produce meaningful errors in current ratio tracking. A few milliohms of trace resistance carrying a few milliamps of current produces microvolts of potential difference between CAT2300 and the SENSEFET. To circumvent this error CAT2300 provides a Kelvin lead (KS) for monitoring the SENSEFET's Sense pin. Under no circumstances should the KS connection share any portion of the current path between the sense pins of CAT2300 and the SENSEFET. Doing so will degrade measurement accuracy.

Kelvin

Kelvin connects directly to the SENSEFET's Kelvin pin and acts the reference voltage for CAT2300's mirroring circuit. It too must be a dedicated connection, shared by no other circuitry.

Gate

Gate connects to the SENSEFET's Gate pin and controls the SENSEFET's operation. Gate is controlled by EN: a logic 1 turns the SENSEFET ON, a logic 0 turns it OFF. When ON, voltage is applied to the SENSEFET's gate via a current source inside CAT2300.

By controlling the gate drive current a controlled turn-ON is achieved. Faster turn-on times can be done by adding a supplemental current source to augment the internal current source. Placing a resistor between V_{DD} and Gate will provide extra current and boost turn-on speeds.

For a softer turn-on characteristic, add capacitance between the SENSEFET's Gate and Source pins; approximately 1 nF for every ms of increased delay.

When switching OFF the SENSEFET, Gate provides a strong pull-down, 7.5 mA typical, so the SENSEFET will be switched off quickly.

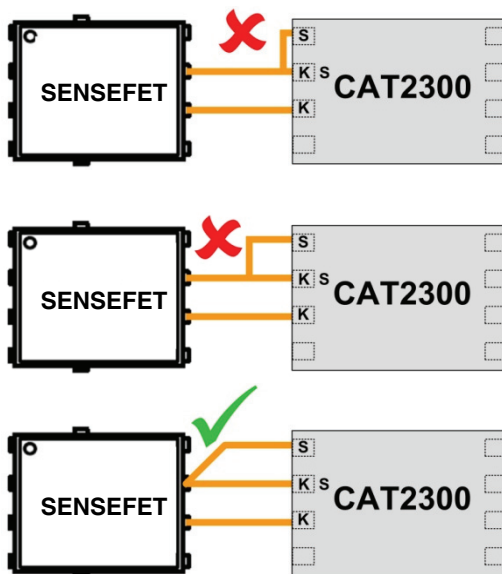


Figure 4. Current Sense

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V_{DD}

V_{DD} provides gate drive for the SENSEFET and power for CAT2300's internal circuitry and must be +5 V.

I_{MEAS}

I_{MEAS} is the mirror current output. Placing a resistor between I_{MEAS} and ground produces a voltage proportional to I_{BUS}. The maximum voltage producible at I_{MEAS} is the Kelvin voltage (V_K) – 0.1 V. This sets a limitation on the maximum value of R_{MEAS}.

$$R_{MEAS} = \frac{(V_K - 0.1 \text{ V})}{I_{SENSE}} = CSR \times \frac{(V_K - 0.1 \text{ V})}{I_{bus}}$$

where:

CSR = Current Sensing Ratio taken from the SENSEFET data sheet.

I_{bus} = Max current through the SENSEFET.

EN

Enable is a high true logic input controlling the SENSEFET's ON/OFF state. A logic high on EN turns the switch ON; a logic low turns it OFF.

Bus turn-ON time is controlled by the FET's input gate capacitance and the drive current applied to the gate.

To minimize power consumption EN disables the internal gate drive current source and current mirroring circuitry whenever the SENSEFET is OFF.

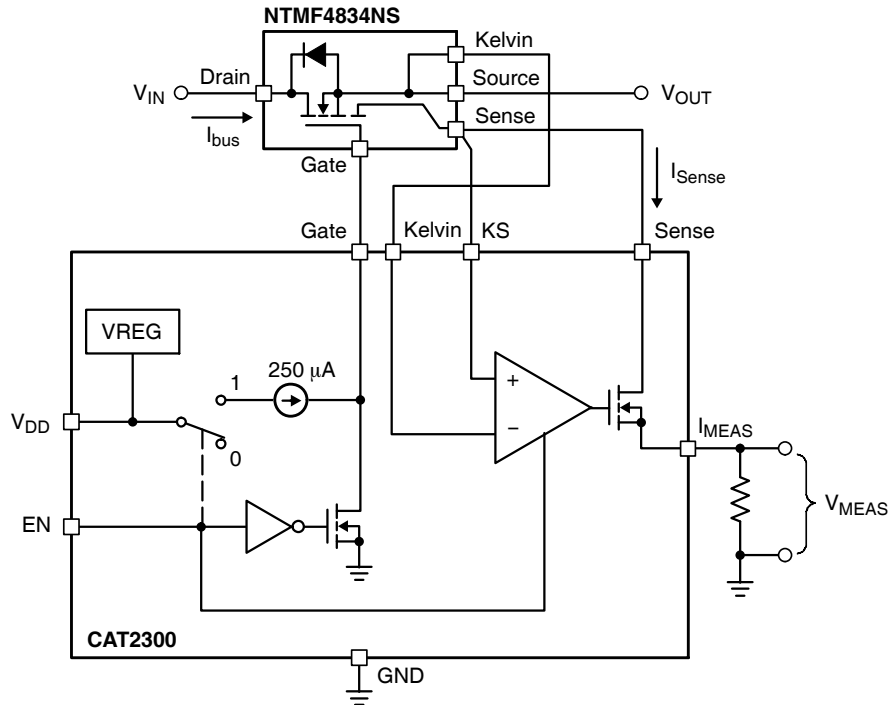
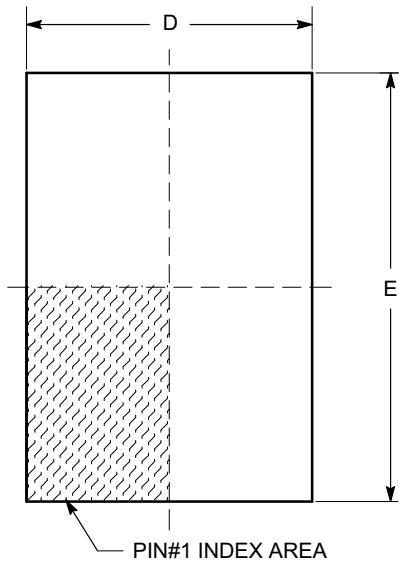


Figure 5. Typical Application

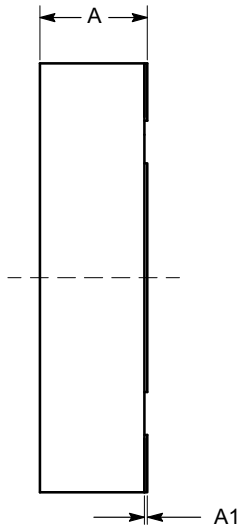
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PACKAGE DIMENSIONS

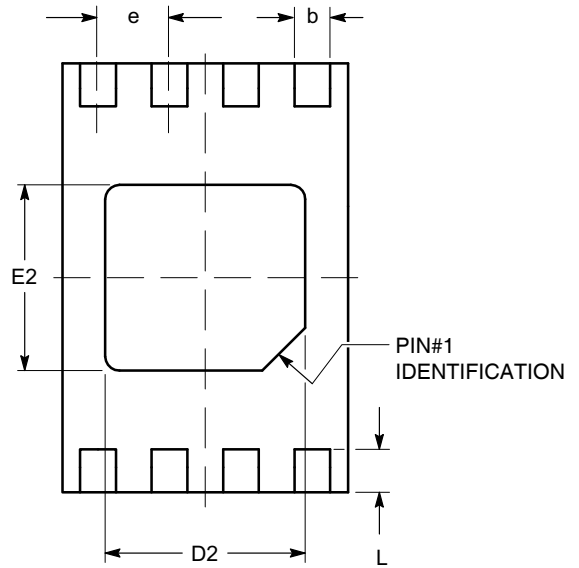
TDFN8, 2x3
CASE 511AK-01
ISSUE A



TOP VIEW

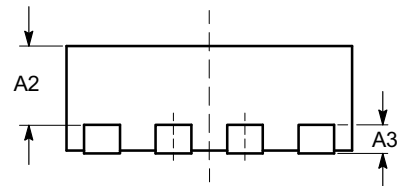


SIDE VIEW



BOTTOM VIEW

SYMBOL	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	0.00	0.02	0.05
A2	0.45	0.55	0.65
A3	0.20 REF		
b	0.20	0.25	0.30
D	1.90	2.00	2.10
D2	1.30	1.40	1.50
E	2.90	3.00	3.10
E2	1.20	1.30	1.40
e	0.50 TYP		
L	0.20	0.30	0.40



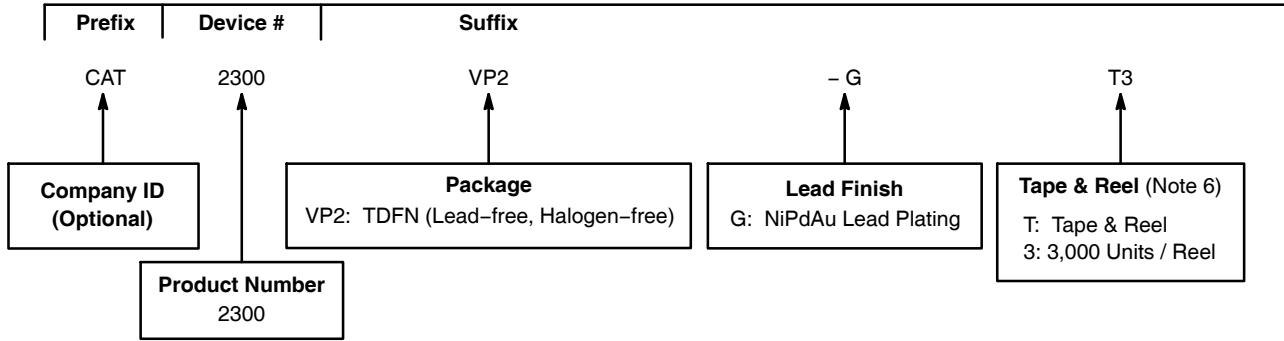
FRONT VIEW

Notes:

- (1) All dimensions are in millimeters.
- (2) Complies with JEDEC MO-229.

CAT2300

Example of Ordering Information (Notes 2 – 5)




ORDERING INFORMATION

Part Number	Temperature Range	Package	Quantity per Reel (Note 6)	Package Marking
CAT2300VP2-GT3	-40°C to +85°C	TDFN	3,000	F3T

- All packages are RoHS-compliant (Lead-free, Halogen-free).
- The standard lead finish is NiPdAu pre-plated (PPF).
- The device used in the above example is a CAT2300VP2-GT3 (TDFN, NiPdAu, Tape & Reel, 3,000).
- For additional package and temperature options, please contact your nearest ON Semiconductor Sales office.
- For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

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