High Voltage 3-Phase Motor Drivers

Features and Benefits

- Built-in bootstrap diodes with limit resistors
- Built-in protection circuit for controlling power supply voltage drop (UVLO)
- Built-in Thermal Shutdown (TSD)
- Built-in Current Limiter (OCL)
- 7.5 V regulated output

Package: 27-pin SOP

Not to scale

Description

The SX68000M series provides the solution for controlling 3-phase full bridges that utilize MOSFETs rated at 250 V/2 A, 500 V/1.5 A, or 500 V/2.5 A.

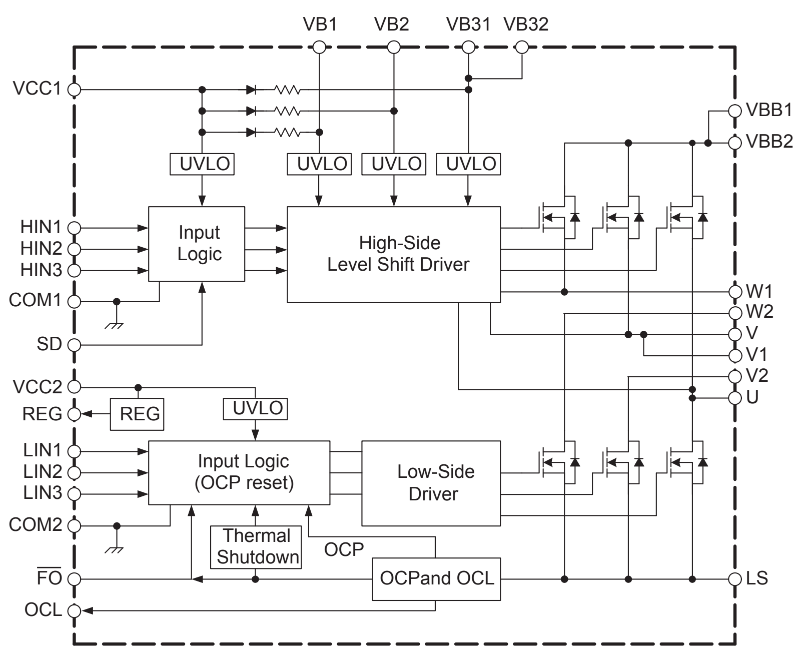
The IC includes in a single package: protection functions such as UVLO (protection circuit for controlling power supply voltage drop), OCP (overcurrent protection), TSD (thermal shutdown), and OCL (current limiting), and a pre-driver with $\overline{FO}$ (Fault Output) terminal and bootstrap diodes with limit resistors.

The SX68000M series is packaged in a fully-molded SOP with 27 pins at 1.2 mm pitch. Body size: 22 × 14.1 × 2.1 mm.

Applications

- Small motor control:
  - Air conditioning fan
  - White goods cooling fans
  - Ventilation blowers

Functional Block Diagram



Selection Guide (Values at T_A = 25℃)

Part Number	Rating		MOSFET V_{DSS} (V)	I_O (A)	I_{OP} (A)	P_D (W)	Thermal Resistance	
	(V)	(A)					Junction to Case, $R_{\theta JC}$ (℃/W)	Junction to Ambient, $R_{\theta JA}$ (℃/W)
SX68001M	250	2	250	2	3	3	15	41.7
SX68002M	500	1.5	500	1.5	2.25			
SX68003M	500	2.5	500	2.5	3.75			

Absolute Maximum Ratings, valid at T_A = 25°C

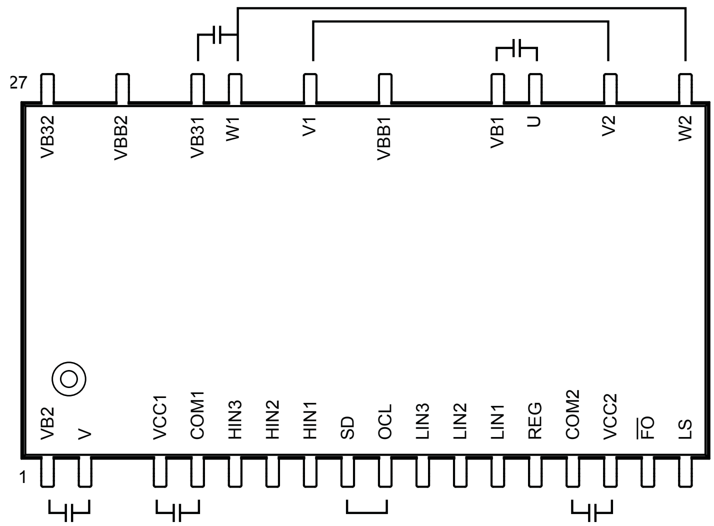
Characteristic	Symbol	Notes		Rating	Unit
MOSFET Breakdown Voltage	V_{DSS}	SX68001M	I_D = 100 μA	250	V
		SX68002M		500	V
		SX68003M		500	V
Logic Supply Voltage	V_{CC}	VCC to COM		20	V
Bootstrap Voltage	V_{BS}	VB to high side (U,V,W)		20	V
Output Current (Continuous)	I_O	SX68001M	T_C = 25°C	2	A
		SX68002M		1.5	A
		SX68003M		2.5	A
Output Current (Pulsed)	I_{OP}	SX68001M	t_W ≤ 100 μs, 1% duty cycle	3	A
		SX68002M		2.25	A
		SX68003M		3.75	A
Output Current for Regulator	I_{REG}			35	mA
Input Voltage	V_{IN}	LINx, HINx, $\overline{FO}$, SD, LS pins		–0.5 to 7	V
Maximum Allowable Power Dissipation*	P_D	T_A = 25°C		3	W
Thermal Resistance (Junction to Case)	$R_{\theta j\text{-}c}$	All circuits operating		15	°C/W
Thermal Resistance (Junction to Ambient)*	$R_{\theta j\text{-}a}$	All circuits operating		41.7	°C/W
Case Operating Temperature	T_{OP}			–20 to 100	°C
Junction Temperature (MOSFET)	T_J			150	°C
Storage Temperature	T_{stg}			–40 to 150	°C

*Mounted on 1.6 mm thick CEM-3 PCB, with 35 μm thick copper layer, without overmolding, in still air.

Recommended Operating Conditions

Characteristic	Symbol	Conditions		Min.	Typ.	Max.	Unit
Main Supply Voltage	V_{BB}	SX68001M	VBB to LS	–	140	200	V
		SX68002M		–	280	400	V
		SX68003M		–	280	400	V
Logic Supply Voltage	V_{CC}		VCC to COM	13.5	–	16.5	V
Dead Time	t_{DEAD}			1.5	–	–	μs
Bootstrap Capacitor	C_{BOOT}			1	–	–	μF
Pull-up Resistor ($\overline{FO}$ pin)	R_{FO}			3.3	–	10	kΩ
Capacitor ($\overline{FO}$ pin)	C_{FO}			0.001	–	0.01	μF
Shunt Resistor (LS pin)	R_S	SX68001M	V_{LS} ≤ 1 V	0.37	–	–	Ω
		SX68002M		0.49	–	–	Ω
		SX68003M		0.30	–	–	Ω
Junction Temperature (MOSFET)	T_J			–	–	125	°C

Pin-out Diagram



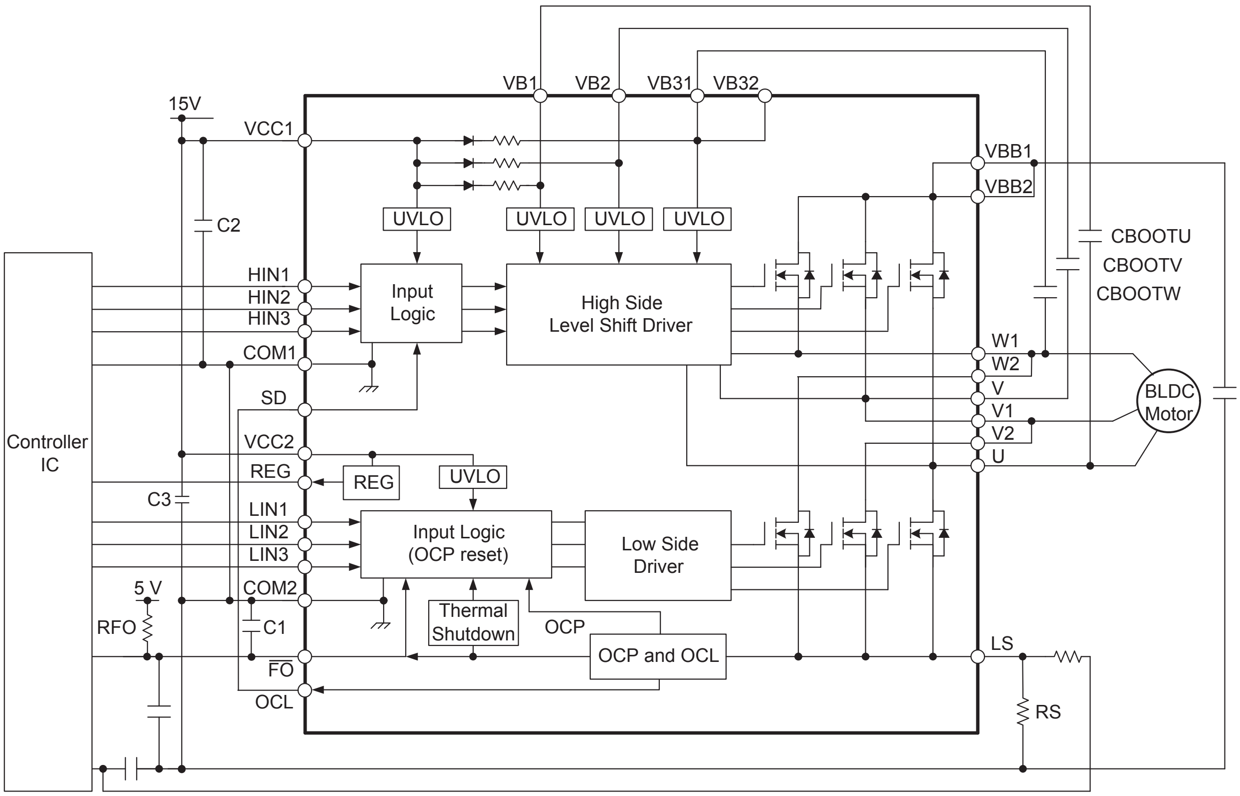
Terminal List Table

Number	Name	Function
1	VB2	High-side bootstrap terminal (V phase)
2	V	Output of V-phase
3	VCC1	High-side logic supply voltage
4	COM1	High-side logic GND terminal
5	HIN3	High-side input terminal (W-phase)
6	HIN2	High-side input terminal (V-phase)
7	HIN1	High-side input terminal (U-phase)
8	SD	High-side shut down input
9	OCL	Current limiter signal output (CMOS output)
10	LIN3	Low-side input terminal (W phase)
11	LIN2	Low-side input terminal (V phase)
12	LIN1	Low-side input terminal (U phase)
13	REG	7.5 V regulator output
14	COM2	Low-side GND terminal
15	VCC2	Low-side logic supply voltage
16	$\overline{FO}$	Fault signal output (open collector output)
17	LS	Low-side MOSFET source terminal
18	W2	Output of W phase (connect to W1)
19	V2	Output of V phase (connect to V1)
20	U	Output of U phase
21	VB1	High-side bootstrap terminal (U phase)
22	VBB1	Main supply voltage 1 (connect VBB2 externally)
23	V1	Output of V phase (connect to V2)
24	W1	Output of W phase (connect to W2)
25	VB31	High side bootstrap terminal (W phase)
26	VBB2	Main supply voltage 2 (connect VBB1 externally)
27	VB32	High side bootstrap terminal (W phase)

All performance characteristics given are typical values for circuit or system baseline design only and are at the nominal operating voltage and an ambient temperature, T_A, of 25°C, unless otherwise stated.

Typical Application Circuit

Using current limiter function



To avoid malfunctions or permanent damage to the IC, observe the following guidelines for layout of the PCB:

- W1 and W2, as well as V1 and V2 must be externally connected to each other.
- If not using the Current Limiter (OCL) function, leave the OCL and SD pins open, but the SD pin should be connected to GND if significant external noise is observed.
- Place a pull-up resistor, RFO, between the 5 V or 3.3 V supply and the IC, selected according to anti-noise characteristics, even though a 1 MΩ pull-up resistor is built-in at $\overline{FO}$ pin. Note that connecting to the 5 V or 3.3 V supply without a pull-up resistor disables the TSD function (however, low-side UVLO protection and OCP function remain active).
- To avoid malfunctions resulting from noise interference, place a 0.01 to 0.1 μF ceramic capacitor (C1) between the $\overline{FO}$ and COM2 pins.
- To avoid malfunctions resulting from noise interference, the traces must be as short as possible between the IC and the bootstrap capacitors, CBOOTx (≈1 μF).
- One of the bootstrap capacitors for the W phase can be populated between pin 24 (W1) and pin 25 (VB31). Also, because pin 27 (VB32) and pin 25 are internally connected, pin 27 can be left open.
- To avoid malfunctions resulting from noise interference, place a 0.01 to 0.1 μF ceramic capacitor between the VCC1 and COM1 (C2), as well as the VCC2 and COM2 (C3) pins. Also, the traces between them must be as short as possible.
- To avoid malfunctions resulting from noise interference, the traces between the current sense resistor RS, which is placed between the LS and COM2 pins, and the IC must be as short and wide as possible.
- If the generated voltage on the LS pin exceeds 7 V, add a Zener diode between the LS and COM2 pins.

SX6800xM ELECTRICAL CHARACTERISTICS Valid T_A = 25°C; unless otherwise noted

Characteristics	Symbol	Test Conditions		Min.	Typ.	Max.	Unit
Logic Supply Current	I_{CC}	V_{CC} = 15 V, I_{REG} = 0 A		–	4.6	8.5	mA
Bootstrap Supply Current	I_B	VB = 15 V, HIN = 5 V per phase		–	140	400	µA
Input Voltage	V_{IH}	V_{CC} = 15 V, Output on		–	2	2.5	V
	V_{IL}	V_{CC} = 15 V, Output off		1	1.5	–	V
$\overline{FO}$ Input Threshold Voltage	V_{FOIH}	V_{CC} = 15 V, Output on		–	2	2.5	V
	V_{FOIL}	V_{CC} = 15 V, Output off		1	1.5	–	V
Input Current	I_{IH}	V_{CC} = 15 V, V_{IN} = 5 V		–	230	500	µA
	I_{IL}	V_{IN} = 0 V		–	–	2	µA
High-Side Undervoltage Lock Out	V_{UVHL}	Between VB and U, V, or W		9.0	10.0	11.0	V
	V_{UVHH}			9.5	10.5	11.5	V
Low-Side Under Voltage Lock Out	V_{UVLL}	Between VCC and COM		10.0	11.0	12.0	V
	V_{UVLH}			10.5	11.5	12.5	V
$\overline{FO}$ Terminal Output Voltage	V_{FOL}	V_{CC} = 15 V,V_{FO} = 5 V, R_{FO} = 10 kΩ		0	–	0.5	V
	V_{FOH}			4.8	–	–	V
Overcurrent Limit Output Voltage	V_{OCLL}	V_{CC} = 15 V		0	–	0.5	V
	V_{OCLH}			4.5	–	5.5	V
Current Limit Reference Voltage	V_{LIM}	V_{CC} = 15 V		0.6175	0.65	0.6825	V
Overcurrent Protection Trip Voltage	V_{TRIP}	V_{CC} = 15 V		0.9	1.0	1.1	V
Overcurrent Protection Hold Time	t_P	V_{CC} = 15 V		20	25	–	µs
Overcurrent Protection Blanking Time	$t_{bk(ocp)}$	V_{CC} = 15 V		–	2	–	µs
Overcurrent Limit Blanking Time	$t_{bk(ocl)}$	V_{CC} = 15 V		–	2	–	µs
SD Terminal Blanking Time	$t_{bk(SD)}$	V_{CC} = 15 V		–	3.3	–	µs
Overtemperature Protection Activating and Releasing Temperature	T_{DH}	V_{CC} = 15 V, no heatsink and I_{REG} = 0 mA		135	150	165	°C
	T_{DL}			105	120	135	°C
Output Voltage for Regulator	V_{REG}	I_{REG} = 35 mA		6.75	7.5	8.25	V
Bootstrap Diode Leakage Current	I_{LBD}	SX68001M	V_R = 250 V	–	–	10	µA
		SX68002M	V_R = 500 V	–	–	10	µA
		SX68003M	V_R = 500 V	–	–	10	µA
Bootstrap Diode Forward Voltage	V_{FBD}	I_F = 0.15 A		–	1.0	1.3	V
Bootstrap Diode Series Resistor	R_{BD}			48	60	72	Ω
MOSFET Leakage Current	I_{DSS}	SX68001M	V_{DS} = 250 V	–	–	100	µA
		SX68002M	V_{DS} = 500 V	–	–	100	µA
		SX68003M	V_{DS} = 500 V	–	–	100	µA
MOSFET On State Resistance	$R_{DS(on)}$	SX68001M	V_{CC} = 15 V, I_D = 1 A, V_{IN} = 5 V	–	1.25	1.5	Ω
		SX68002M	V_{CC} = 15 V, I_D = 0.75 A, V_{IN} = 5 V	–	3.2	4.0	Ω
		SX68003M	V_{CC} = 15 V, I_D = 1.25 A, V_{IN} = 5 V	–	2.0	2.4	Ω
Diode Forward Voltage (MOSFET)	V_{SD}	SX68001M	V_{CC} = 15 V, I_{SD} = 1 A, V_{IN} = 0 V	–	1.1	1.5	V
		SX68002M	V_{CC} = 15 V, I_{SD} = 0.75 A, V_{IN} = 0 V	–	1.0	1.5	V
		SX68003M	V_{CC} = 15 V, I_{SD} = 1.25 A, V_{IN} = 0 V	–	1.0	1.5	V

SX68001M SWITCHING CHARACTERISTICS Valid T_A = 25°C; unless otherwise noted

Characteristics	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
High-Side Switching Time	$t_{dH(on)}$	V_{BB} = 150 V, V_{CC} = 15 V, I_D = 1 A, 0 V < V_{IN} < 5 V, see Switching Time Definition diagram	–	800	–	ns
	t_{rH}		–	45	–	ns
	t_{rrH}		–	75	–	ns
	$t_{dH(off)}$		–	720	–	ns
	t_{fH}		–	40	–	ns
Low-Side Switching Time	$t_{dL(on)}$	V_{BB} = 150 V, V_{CC} = 15 V, I_D = 1 A, 0 V < V_{IN} < 5 V, see Switching Time Definition diagram	–	750	–	ns
	t_{rL}		–	50	–	ns
	t_{rrL}		–	70	–	ns
	$t_{dL(off)}$		–	660	–	ns
	t_{fL}		–	20	–	ns

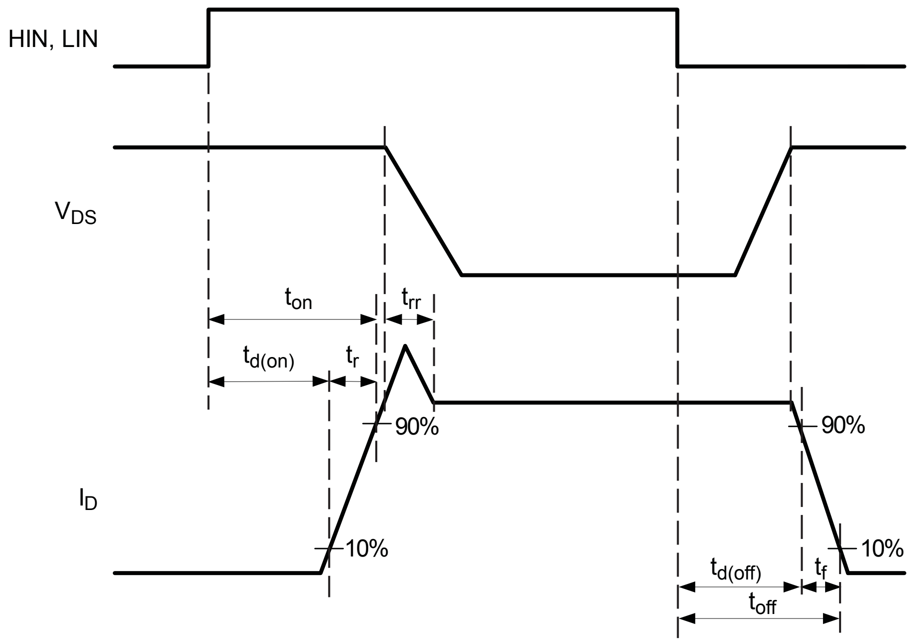
SX68002M SWITCHING CHARACTERISTICS Valid T_A = 25°C; unless otherwise noted

Characteristics	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
High-Side Switching Time	$t_{dH(on)}$	V_{BB} = 300 V, V_{CC} = 15 V, I_D = 0.75 A, 0 V < V_{IN} < 5 V, see Switching Time Definition diagram	–	810	–	ns
	t_{rH}		–	60	–	ns
	t_{rrH}		–	120	–	ns
	$t_{dH(off)}$		–	815	–	ns
	t_{fH}		–	40	–	ns
Low-Side Switching Time	$t_{dL(on)}$	V_{BB} = 300 V, V_{CC} = 15 V, I_D = 0.75 A, 0 V < V_{IN} < 5 V, see Switching Time Definition diagram	–	760	–	ns
	t_{rL}		–	60	–	ns
	t_{rrL}		–	110	–	ns
	$t_{dL(off)}$		–	750	–	ns
	t_{fL}		–	30	–	ns

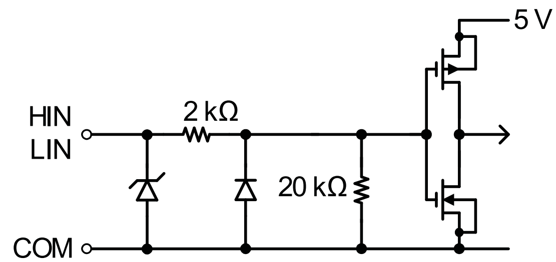
SX68003M SWITCHING CHARACTERISTICS Valid T_A = 25°C; unless otherwise noted

Characteristics	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
High-Side Switching Time	$t_{dH(on)}$	V_{BB} = 300 V, V_{CC} = 15 V, I_D = 1.25 A, 0 V < V_{IN} < 5 V, see Switching Time Definition diagram	–	940	–	ns
	t_{rH}		–	100	–	ns
	t_{rrH}		–	135	–	ns
	$t_{dH(off)}$		–	975	–	ns
	t_{fH}		–	45	–	ns
Low-Side Switching Time	$t_{dL(on)}$	V_{BB} = 300 V, V_{CC} = 15 V, I_D = 1.25 A, 0 V < V_{IN} < 5 V, see Switching Time Definition diagram	–	900	–	ns
	t_{rL}		–	105	–	ns
	t_{rrL}		–	135	–	ns
	$t_{dL(off)}$		–	905	–	ns
	t_{fL}		–	35	–	ns

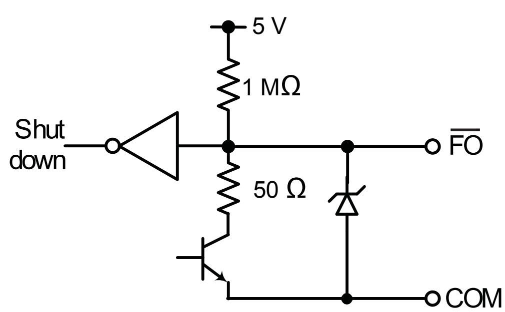
Switching Time Definition



HIN, LIN Internal Equivalent Circuit

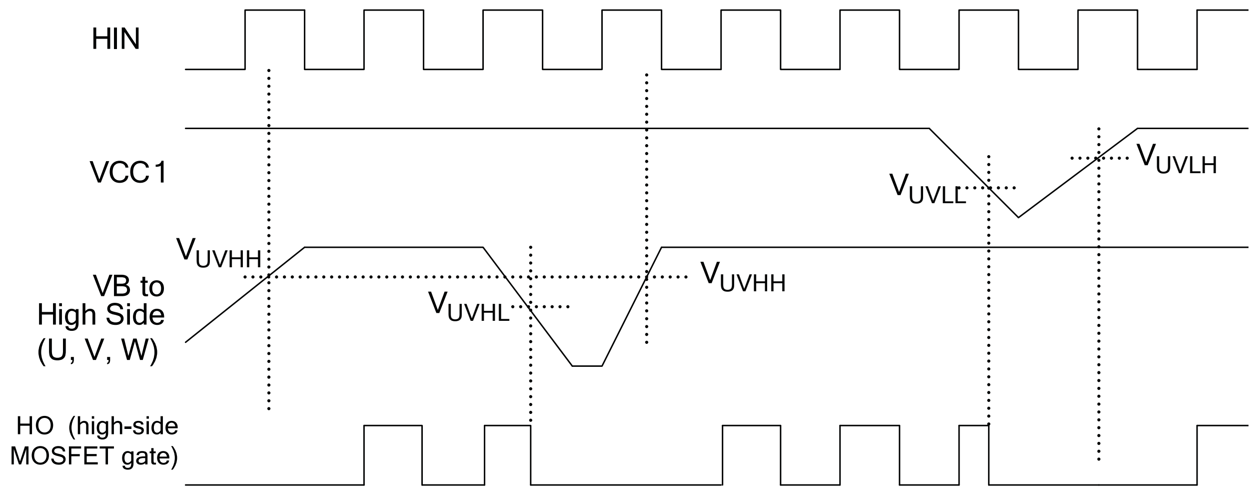


$\overline{FO}$ Internal Equivalent Circuit

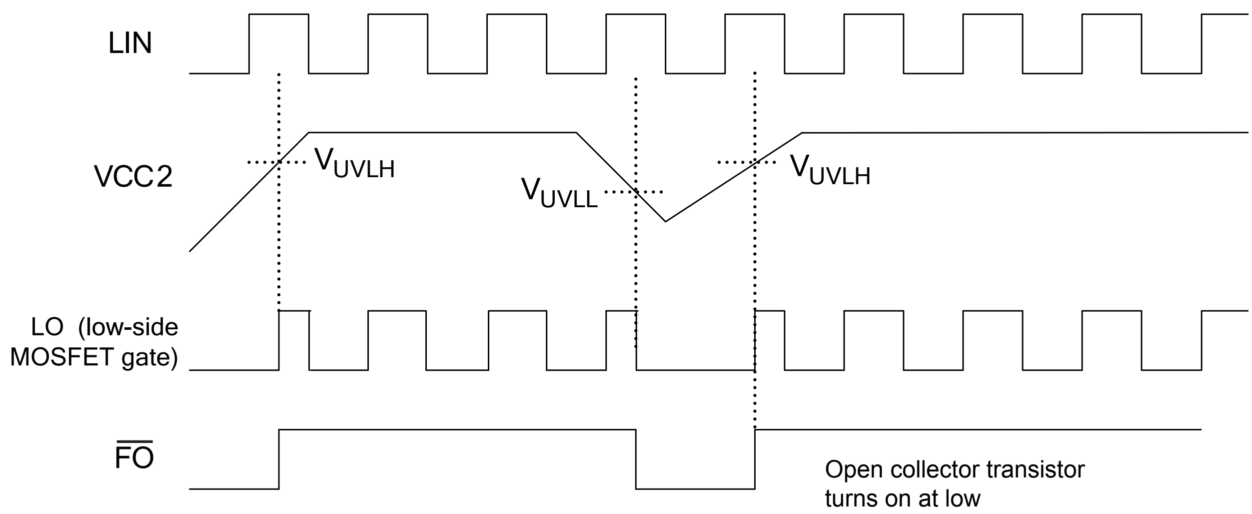


Protection Circuit Timing

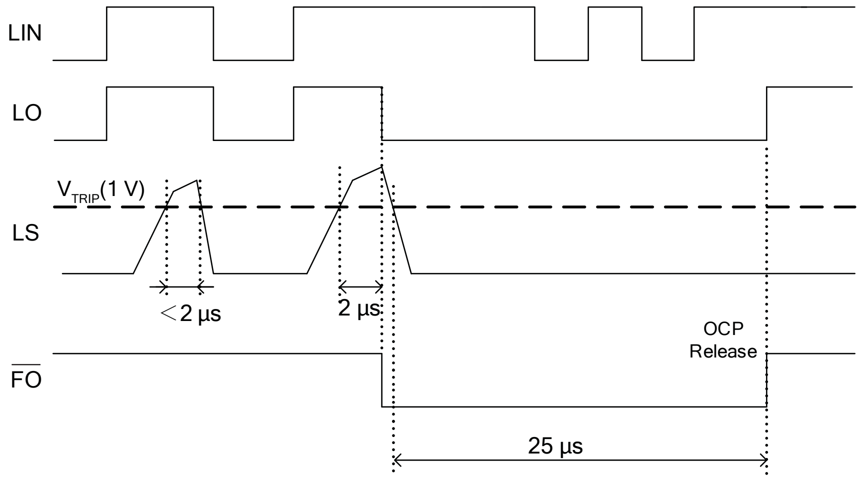
UVLO Protection Circuit - High Side Timing



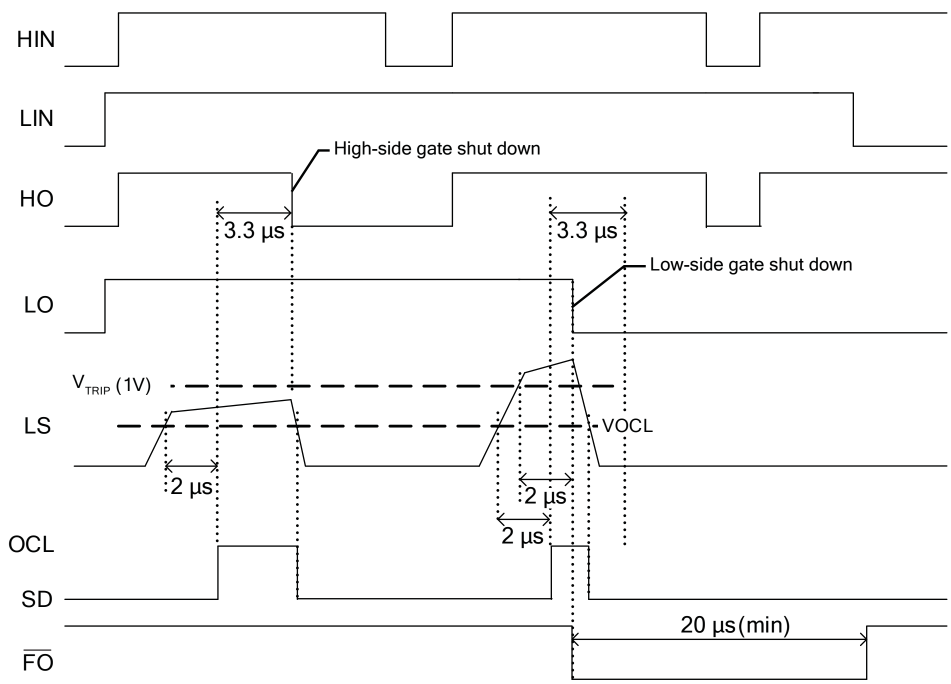
UVLO Protection Circuit - Low Side Timing



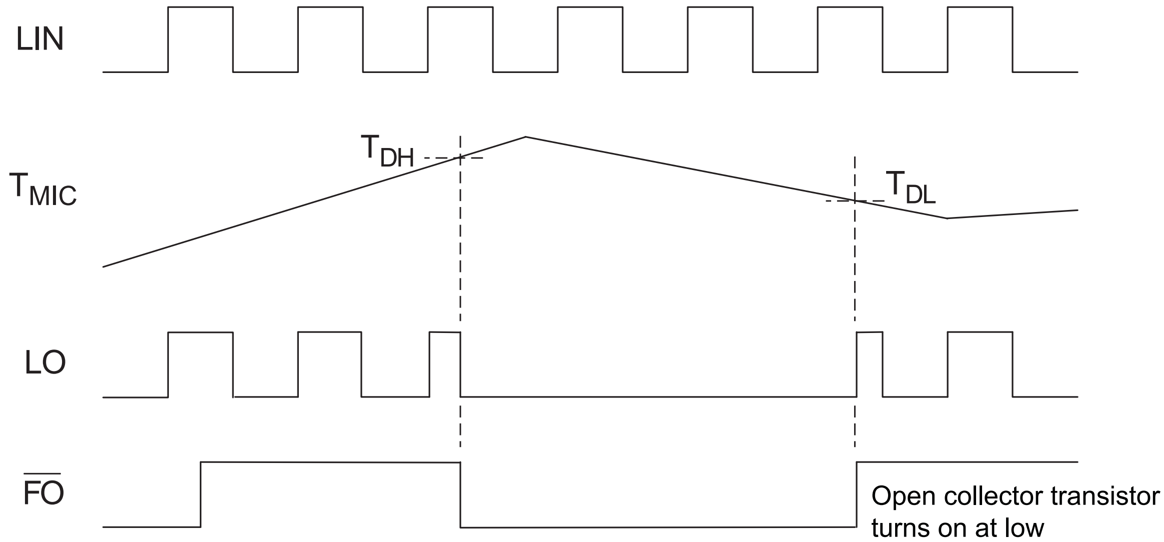
OCP Protection CircuitTiming



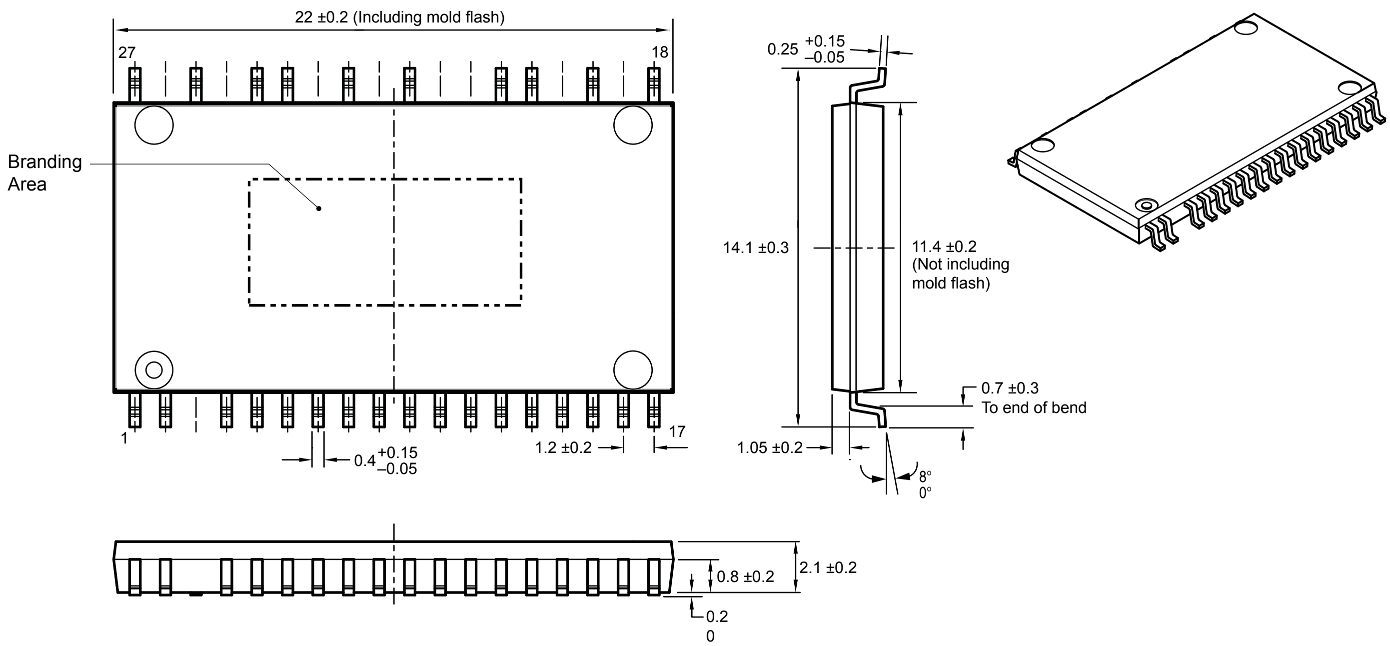
OCL Protection CircuitTiming (OCL and SD connected)

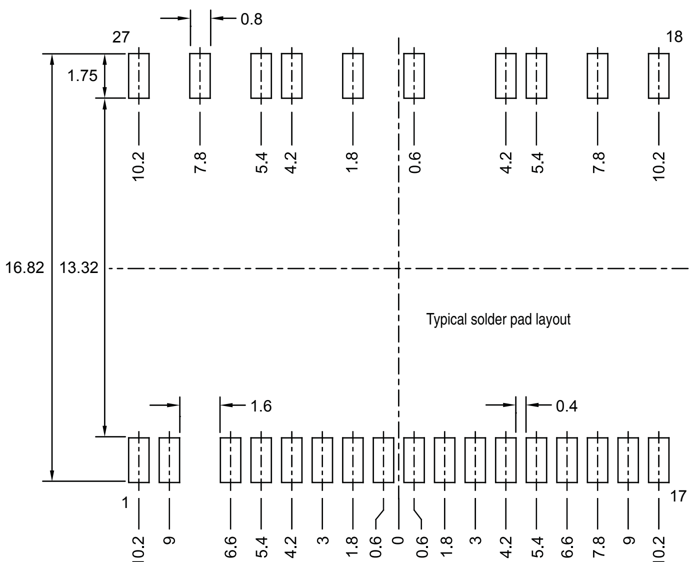


TSD Protection CircuitTiming



Package Outline Drawing, SOP-27





Terminal core material: Cu
Terminal treatment: Solder plating (Sn 97.5%, Ag 2.5%)
Leadframe: LF1890

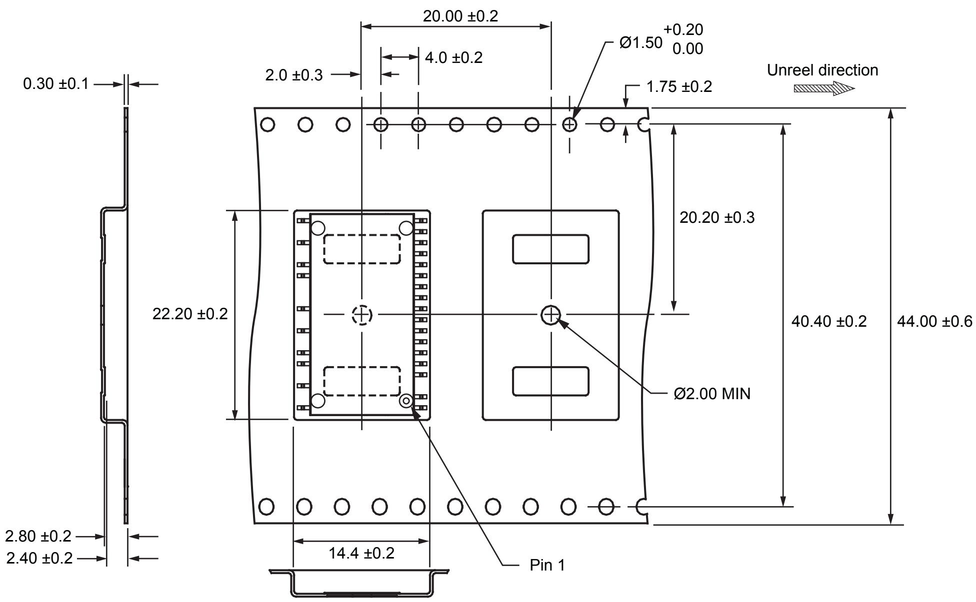
Dimensions in millimeters

Branding codes (exact appearance at manufacturer discretion):
1st line, type: SX6800xM

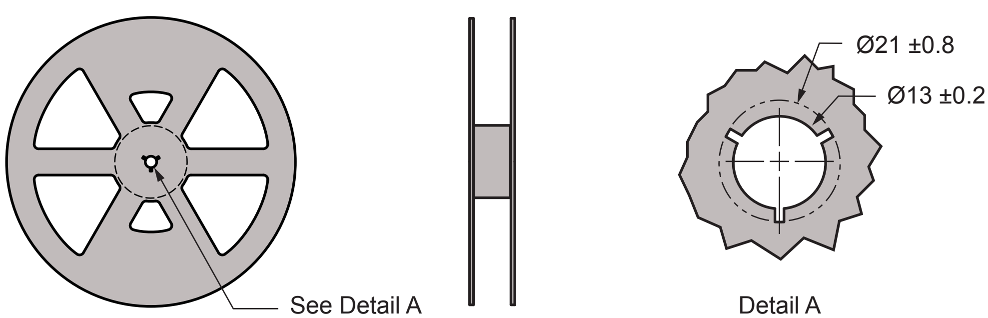
2nd line, logo: SK lot: *YMDDR*
Where: Y is the last digit of the year of manufacture
M is the month (*1* to *9, O, N, D*)
DD is the day of the month (*01* to *31*)
R is a reference number

Allegro MicroSystems, Inc.
115 Northeast Cutoff
Worcester, Massachusetts 01615-0036 U.S.A.
1.508.853.5000; www.allegromicro.com

Packing Specification

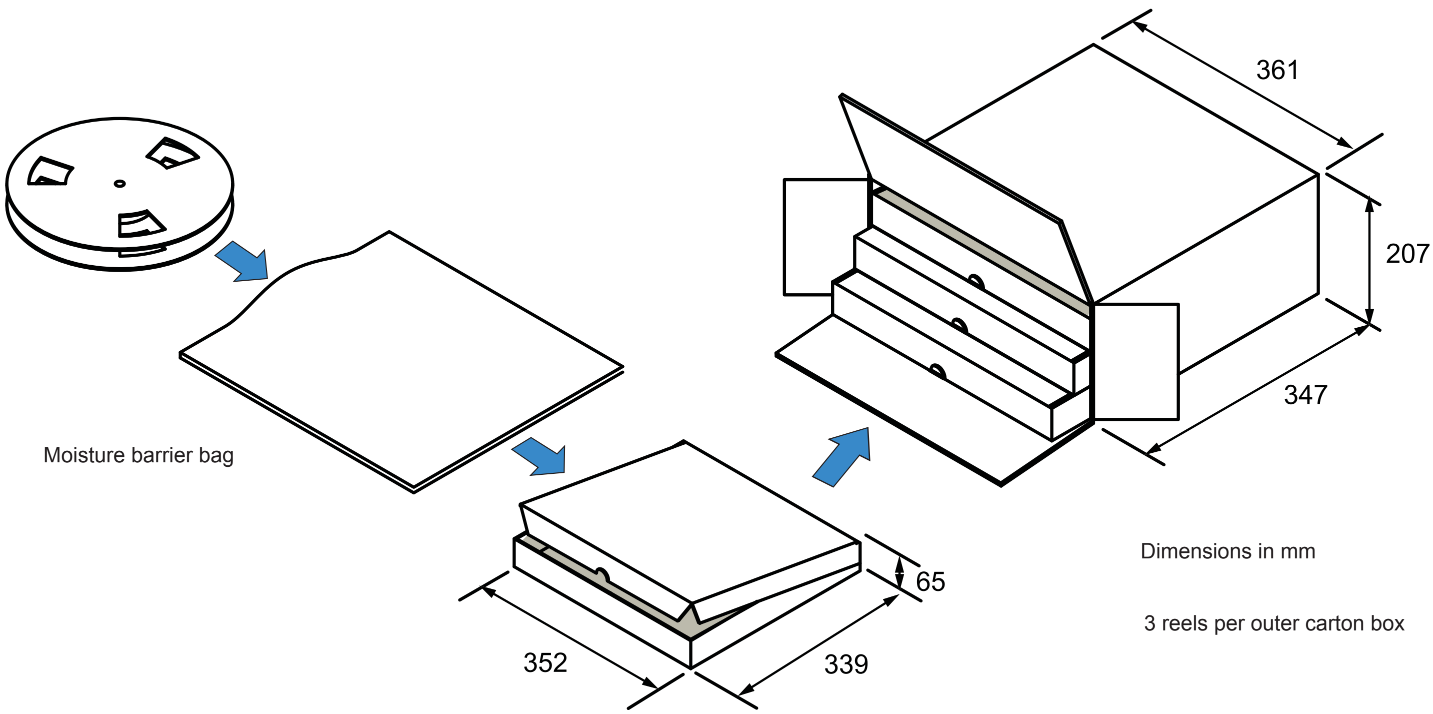


Conductive polysytrene; cumulative pitch of sprocket holes ± 0.2 mm for 10-pitch span



Access hole and hub configuration may vary
at supplier discretion within limits shown

1,000 pieces per reel
Leader tape ≥ 100 mm, empty pockets sealed ≥ 400 mm from leading edge
Trailer tape ≥ 100 mm, empty pockets sealed


361
207
347
Moisture barrier bag
65
352
339
Dimensions in mm
3 reels per outer carton box

WARNING — These devices are designed to be operated at lethal voltages and energy levels. Circuit designs that embody these components must conform with applicable safety requirements. Precautions must be taken to prevent accidental contact with power-line potentials. Do not connect grounded test equipment.

The use of an isolation transformer is recommended during circuit development and breadboarding.

Because reliability can be affected adversely by improper storage environments and handling methods, please observe the following cautions.

Cautions for Storage

- Ensure that storage conditions comply with the standard temperature (5°C to 35°C) and the standard relative humidity (around 40 to 75%); avoid storage locations that experience extreme changes in temperature or humidity.
- Avoid locations where dust or harmful gases are present and avoid direct sunlight.
- Reinspect for rust on leads and solderability of products that have been stored for a long time.

Cautions for Testing and Handling

When tests are carried out during inspection testing and other standard test periods, protect the products from power surges from the testing device, shorts between adjacent products, and shorts to the heatsink.

Remarks About Using Silicone Grease with a Heatsink

- When silicone grease is used in mounting this product to a heatsink, it shall be applied evenly and thinly. If more silicone grease than required is applied, it may produce stress.
- Volatile-type silicone greases may permeate the product and produce cracks after long periods of time, resulting in reduced heat radiation effect, and possibly shortening the lifetime of the product.
- Our recommended silicone greases for heat radiation purposes, which will not cause any adverse effect on the product life, are indicated in the following table:

Type	Suppliers
G746	Shin-Etsu Chemical Co., Ltd.
YG6260	Momentive Performance Materials, Inc.
SC102	Dow Corning Toray Silicone Co., Ltd.

Soldering

- When soldering the products, please be sure to minimize the working time, within the following limits:
  260±5°C 10 s
  380±5°C 5 s, using soldering iron
- Soldering iron should be at a distance of at least 1.5 mm from the body (resin case) of the products

Electrostatic Discharge

- When handling the products, operator must be grounded. Grounded wrist straps worn should have at least 1 MΩ of resistance to ground to prevent shock hazard.
- Workbenches where the products are handled should be grounded and be provided with conductive table and floor mats.
- When using measuring equipment such as a curve tracer, the equipment should be grounded.
- When soldering the products, the head of soldering irons or the solder bath must be grounded in other to prevent leak voltages generated by them from being applied to the products.
- The products should always be stored and transported in our shipping containers or conductive containers, or be wrapped in aluminum foil.

The products described herein are manufactured in Japan by Sanken Electric Co., Ltd. for sale by Allegro MicroSystems, Inc.

Sanken and Allegro reserve the right to make, from time to time, such departures from the detail specifications as may be required to permit improvements in the performance, reliability, or manufacturability of its products. Therefore, the user is cautioned to verify that the information in this publication is current before placing any order.

When using the products described herein, the applicability and suitability of such products for the intended purpose shall be reviewed at the users responsibility.

Although Sanken undertakes to enhance the quality and reliability of its products, the occurrence of failure and defect of semiconductor products at a certain rate is inevitable.

Users of Sanken products are requested to take, at their own risk, preventative measures including safety design of the equipment or systems against any possible injury, death, fires or damages to society due to device failure or malfunction.

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When considering the use of Sanken products in applications where higher reliability is required (transportation equipment and its control systems or equipment, fire- or burglar-alarm systems, various safety devices, etc.), contact a company sales representative to discuss and obtain written confirmation of your specifications.

The use of Sanken products without the written consent of Sanken in applications where extremely high reliability is required (aerospace equipment, nuclear power-control stations, life-support systems, etc.) is strictly prohibited.

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