Solid State Relay for Automotive Flasher Applications

This device is a Dual High-Side Power Switch dedicated for automotive flasher applications. In comparison with mechanical solutions, this device offers higher reliability as well as protection and diagnostic features.

The device consists of two 25 mΩ Rdson fully protected high side switches, in a surface mount power package. It interfaces directly with a microcontroller and includes a current recopy function in order to allow the detection of a failed lamp in the application.

Features

- Junction Temperature Range from -40°C to 150°C
- Operating Voltage Range from 8.0 V to 35 V
- Maximum Breakdown Voltage greater than 40 V
- 25 mΩ $R_{DS(ON)}$ per Channel at 25°C
- 8.0 Amps Nominal Current per Channel
- 1.2 W Warning Lamp Driver
- Overtemperature Protection with Hysteresis
- Open Load Detection in ON State
- Current Recopy to Monitor Lamp Output Current

- Standby Current < 10 µA at V_{BAT} < 14 V

33288

SOLID STATE RELAY
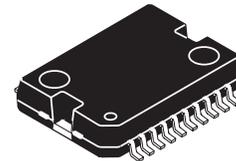
DH SUFFIX
98ASH70273A
20-LEAD HSOP

ORDERING INFORMATION

Device	Temperature Range (T_A)	Package
MC33288DDH/R2	-40°C to 125°C	20 HSOP

Simplified Application Diagram
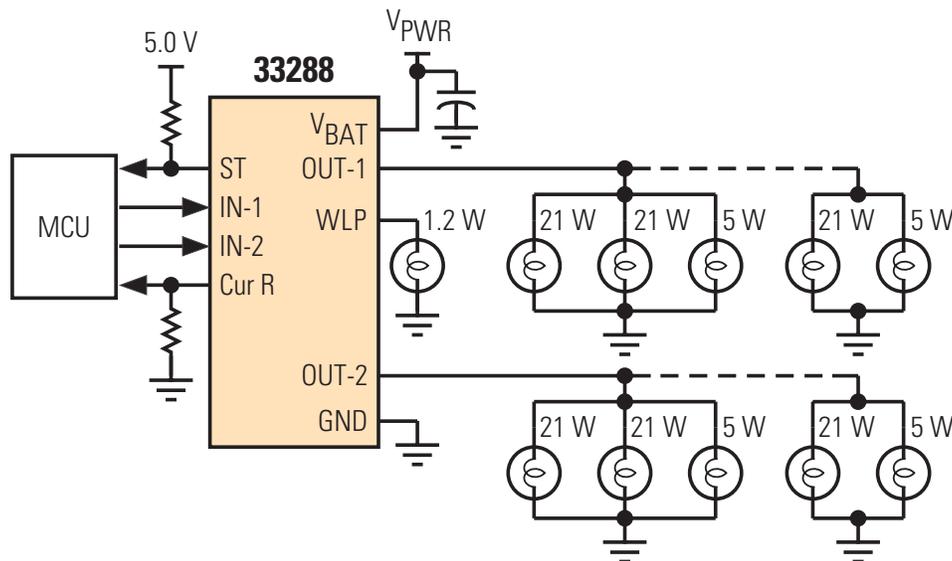
Figure 1. 33288 Simplified Internal Block Diagram

freescale™
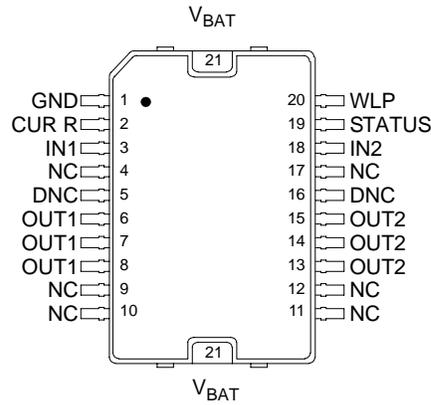semiconductor

TERMINAL CONNECTIONS

V_{BAT}

Figure 2. 33288 Terminal Connections

Table 1. 33288 Terminal Definitions

A functional description of each terminal can be found in the Functional Description section beginning on <u>7</u>.

Terminal Number	Terminal Name	Formal Name	Definition
TAB	V_{BAT}	Supply Voltage	The backside TAB is connected to the power supply of the MC33288DH.
2	CUR R	Load Current Sense	The Current Sense terminal delivers a ratioed amount (1/1000) of the sum of the currents that can be used to generate signal ground referenced output voltages for use by the microcontroller.
3 18	IN1 IN2	INPUT Channel 1 INPUT Channel 2	These are the device input terminals which directly control their associated outputs.
4, 9, 10, 11, 12, 17	NC	No Connect	These terminals are not used.
5, 16	DNC	Do Not Connect	These terminals must not be connected.
6, 7, 8 13, 14, 15	OUT1 OUT2	OUTPUT Channel 1 OUTPUT Channel 2	They deliver current to the connected loads and are controlled via the IN1 terminals. They deliver current to the connected loads and are controlled via the IN2 terminals,
11	GND	Ground	This is the ground terminal of the device.
19	STATUS	Status for Both Channels	The Fault output is an open drain indication that goes active low when a fault mode (Openload, Overtemperature) is detected by the device.
20	WLP	Warning Lamp Output	It delivers current through the connected load.

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MAXIMUM RATINGS

Table 2. Maximum Ratings

All voltages are with respect to ground unless otherwise noted. Exceeding these ratings may cause a malfuncion or permanent damage to the device.

Ratings	Symbol	Value	Unit
ELECTRICAL RATINGS			
V_{BAT} Voltage with Respect to GND : Continuous/Pulse	V_{BAT}	-14 to 40	V
OUT1 and OUT2 Voltage with Respect to GND : Continuous/Pulse	V_{OUT}	-0.3 to 40	V
OUT1 to V_{BAT} and OUT2 to V_{BAT} Voltage : Continuous/Pulse	V_{OUT}	40	V
IN1, IN2, St DC Voltage : Continuous/Pulse	V_{IN}	-0.3 to 7.0	V
CUR R Voltage : Continuous/Pulse	V_{CR}	-0.3 to 7.0	V
ESD All Pins Human Body Model [1] Machine Model [2]	V_{ESD1} V_{ESD2}	 ±2000 ±200	V
OUT1, OUT2 Output Current : Pulse [3]	I_{OUTP}	40	A
IN1, IN2, STATUS	I_{IN}	±5.0	mA
THERMAL RATINGS			
Junction Temperature	T_J	-40 to 150	°C
Storage Temperature Range	$T_{STORAGE}$	-65 to 150	°C
Thermal Resistance Junction to Case	$R_{\theta JC}$	2.0	°C/W
Thermal Resistance Junction to Ambient [4]	$R_{\theta JA}$	25	°C/W
Power Dissipation at Tcase 140°C [5]	P_D	5.0	W

Notes
1. ESD1 testing is performed in accordance with the Human Body Model (C_{ZAP}=100 pF, R_{ZAP}=1500 Ω).
2. ESD2 testing is performed in accordance with the Machine Model (C_{ZAP}=200 pF, R_{ZAP}=0 Ω).
3. During lamp inrush current.
4. Device mounted on dual side printed circuit board with 70 μm copper thickness and 10 cm^2 copper heat sink (2.5 cm^2 on top side and 7.5 cm^2 on down side).
5. Assuming a 150°C maximum junction temperature.

STATIC ELECTRICAL CHARACTERISTICS

Table 3. Static Electrical Charactersitics

Characteristics noted under conditions 4.5 V $\leq$ V$_{DD}$ $\leq$ 5.5 V, 9.0 V $\leq$ V$_{PWR}$ $\leq$ 16 V, -40°C $\leq$ T$_A$ $\leq$ 125°C, unless otherwise noted. Typical values noted reflect the approximate parameter mean at T$_A$ = 25°C under nominal conditions, unless otherwise noted.

Characteristic	Symbol	Min	Typ	Max	Unit
POWER INPUT					
Nominal Operating Voltage	V$_{BAT}$	9	–	16	V
Functional Operating Voltage	V$_{BAT}$	8	–	35	V
Under Voltage Threshold	V$_{\mu V}$	6	7	8	V
V$_{BAT}$ Standby Supply Current V$_{BAT}$ < 14 V and V$_{IN}$ = 0 V, T$_J$ < 125°C	I$_{STDBY}$	–	1	10	μA
Supply Current in ON State IN1 and IN2 @ 3.5 V, no fault, V$_{BAT}$ < 14 V, T$_J$ < 125°C	I$_{ON}$	–	8	20	mA
Drain to Source on Resistance I$_{OUT}$ = 4.0 A, V$_{BAT}$ > 9.0 V and T$_J$ = 25°C	R$_{DSON}$	–	20	25	mΩ
Drain to Source on Resistance I$_{OUT}$ = 4.0 A, V$_{BAT}$ > 9.0 V and T$_J$ = 150°C	R$_{DSON}$	–	30	40	mΩ
High Current Limitation V$_{OUT}$ > 1.0 V	I$_{LIM}$	–	30	–	A
Short Circuit limitation V$_{OUT}$ < 1.0 V, T$_J$ = 25°C	I$_{LIM}$	–	4	–	A
Hot Openload Threshold	I$_{OL}$	–	1	–	A
V$_{BAT}$ to Output Breakdown Voltage IN1 and IN2 @ 0 V, V$_{OUT}$ = 0 V, I$_{OUT}$ -0.25 mA	V$_{DSS}$	40	–	–	A
V$_{BAT}$ to OUT1 : Leakage Current V$_{IN1}$ = 0 V, V$_{BAT}$ = 35 V, V$_{OUT1}$ = 0 V	I$_{OUT-LEAK}$	–	–	10	μA
V$_{BAT}$ to OUT2 : Leakage Current V$_{IN2}$ = 0 V, V$_{BAT}$ = 35 V, V$_{OUT2}$ = 0 V	I$_{OUT-LEAK}$	–	–	10	μA
VIN1, VIN2 : Input Voltage Low Threshold	V$_{IL}$	–	–	1.5	V
VIN1, VIN2 : Input Voltage High Threshold	V$_{IH}$	3.5	–	–	V
VIN1, VIN2 : Input Voltage Hysteresis	V$_{IH}$	0.4	0.7	0.9	V
VIN1, VIN2 : Input Current V$_{IN1}$, V$_{IN2}$ = 3.5 V	I$_{IN}$	–	18	40	μA
Status Output Voltage Ist = 1 mA; Output in Fault	Vst	–	–	0.5	V
Thermal Shutdown	T$_{SHUT}$	150	–	–	°C
Thermal Shutdown Hysteresis	T$_{HYST}$	–	10	–	°C

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Table 3. Static Electrical Charactersitics(continued)

Characteristics noted under conditions 4.5 V $\leq$ V$_{DD}$ $\leq$ 5.5 V, 9.0 V $\leq$ V$_{PWR}$ $\leq$ 16 V, -40°C $\leq$ T$_A$ $\leq$ 125°C, unless otherwise noted. Typical values noted reflect the approximate parameter mean at T$_A$ = 25°C under nominal conditions, unless otherwise noted.

Characteristic	Symbol	Min	Typ	Max	Unit
Current Recopy Ratio V$_{OUT}$ > V$_{BAT}$ -1.0 V, I$_{OUT}$ from 2.0 A to 4.0 A T$_J$ -40°C to 105°C, V$_{BAT}$ 9.0 V to 16 V	C$_R$	–	1/1000	–	µA
Current Recopy Ratio Accuracy V$_{OUT}$ > V$_{BAT}$ -1.0 V, I$_{OUT}$ from 2.0 A to 4.0 A T$_J$ -40°C to 105°C, V$_{BAT}$ 9.0 V to 16 V	C$_{R-AC}$	-10	–	10	%
Extended Current Recopy Ratio V$_{OUT}$ > V$_{BAT}$ -1.0 V, I$_{OUT}$ from 1.0 A to 8.0 A	C$_{REX}$	–	1/1000	–	%
Extended Current Recopy Ratio Accuracy V$_{OUT}$ > V$_{BAT}$ -1.0 V, I$_{OUT}$ from 1.0 A to 8.0 A	C$_{REX-AC}$	-20	–	20	%
Current Recopy Clamp Voltage At 10mA	V$_{CLST}$	5.5	–	7.0	V
Nominal Flasher Frequency Operation	F$_{FL}$	–	1.5	–	Hz
Frequency Operation	F$_{OP}$	–	–	100	Hz
Nominal Flasher Duty Cycle Operation	D$_{CFL}$	–	50	–	%
WLP Output Drain to Source on Resistance I$_{OUT}$ = 100 mA, V$_{BAT}$ > 9.0 V and T$_J$ = 25°C	R$_{WON}$	–	–	3.2	Ω
WLP Output Drain to Source on Resistance I$_{OUT}$ = 100 mA, V$_{BAT}$ > 9.0 V and T$_J$ = 125°C	R$_{WON}$	–	–	5.0	Ω
WLP Output Current Limitation V$_{OUT}$ = 0 V	I$_{WLIM}$	–	500	–	mA
WLP Thermal Shutdown	T$_{WSHUT}$	150	–	–	°C

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DYNAMIC ELECTRICAL CHARACTERISTICS

Table 4. Dynamic Electrical Characteristics

Characteristics noted under conditions 4.5 V $\leq$ V$_{DD}$ $\leq$ 5.5 V, 9.0 V $\leq$ V$_{PWR}$ $\leq$ 16 V, -40°C $\leq$ T$_A$ $\leq$ 125°C, unless otherwise noted.
Typical values noted reflect the approximate parameter mean at T$_A$ = 25°C under nominal conditions, unless otherwise noted.

Characteristic	Symbol	Min	Typ	Max	Unit
MICROCONTROLLER INTERFACE					
Maximum Output Positive Slew Rate Load = 6.0 Ω	t$_R$	0.01	0.3	2.0	V/μs
Maximum Output Negative Slew Rate Load = 6.0 Ω	t$_F$	0.01	0.3	2.0	V/μs
Turn ON Delay Time Load = 6.0 Ω, from V$_{IN/2}$ to 10% V$_{OUT}$	T$_{DON}$	1.0	30	200	μs
Turn OFF Delay Time Load = 6.0 Ω, from V$_{IN/2}$ to 90% V$_{OUT}$	T$_{DOFF}$	1.0	40	200	μs

FUNCTIONAL DESCRIPTION

INTRODUCTION

The MC33288DH is a dual high side switch with appropriate control, protection, and diagnostic features dedicated to automotive flasher applications. The device consists of two independent 25mW power switches and an additionnal 3.2 Ω high-side switch capable of controlling a 1.2 W warning lamp. It interfaces directly with a microcontroller and the package used is a 20-HSOP power small outline, 20 terminals. The MC33288 incorporates a status terminal and a load current sense capability.

FUNCTIONAL TERMINAL DESCRIPTIONS

SUPPLY VOLTAGE (VBAT)

The backside TAB is connected to the power supply of the MC33288DH. In addition to its supply function, this terminal contributes to the thermal behaviour of the device by conducting the heat from the switching MOSFET to the printed circuit board.

LOAD CURRENT SENSE (CUR R)

The Current Sense terminal delivers a ratioed amount (1/1000) of the sum of the currents that can be used to generate signal ground referenced output voltages for use by the microcontroller.

INPUT CHANNEL 1/2 (IN1, IN2)

These are the device input terminals which directly control their associated outputs. The levels are CMOS compatible. When the input is a logic low, the associated output MOSFET is in the OFF state. When input is high, the MOSFET is turned ON and the load is activated. When both inputs are low, the device is in standby mode and its supply current is reduced. Each input terminal has an internal active pull-down, so that it will not float if disconnected.

OUTPUT CHANNEL (OUT1, OUT2)

Pins 6, 7, and 8 are the source of the output 1 25 mΩ MOSFET1. Pins 13, 14, and 15 are the source of the output 2 25 mΩ MOSFET2. They deliver current to the connected loads and are controlled via the IN1 and IN2 terminals, respectively . These outputs are current limited and thermally protected.

GROUND (GND)

This is the ground terminal of the device.

STATUS FOR BOTH CHANNELS (STATUS)

The Fault output is an open drain indication that goes active low when a fault mode (Openload, Overtemperature) is detected by the device on either one channel or both channels simultaneously. Its internal structure is an open drain architecture with an internal clamp at 6.0 V. An external pull-up resistor connected to V_{DD} (5.0 V) is needed.

WARNING LAMP OUTPUT (WLP)

This terminal is the source of a 3.2 Ω MOSFET. This output is current limited and thermally protected. It delivers current through the connected load when both IN1 and IN2 inputs are logic high. It is usually used as a warning lamp driver for Flasher application.

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FUNCTIONAL DEVICE OPERATION

OPERATIONAL MODES

Power Supply

The MC33288 can be directly connected to the supply line. In standby mode (IN1 and IN2 @ OV), the supply current is less than 10 mA for V_{BAT} supply voltage below 14 V. This feature allows a very low supply current on the battery when the car is idle or parked.

During the OFF state, the current recopy terminal and the status terminals are in high impedance.

In case of loss of (digital) ground, the power MOSFETs turn off in order to safely tie the load current to zero.

Nominal Voltage and Transient Operation

The nominal operation voltage is from 9.0 V to 16 V. The MC33288 is functional over a larger voltage range from 8.0 V to 35 V. The technology used for both power and analog circuitry sustains 40 V DC voltage.

Reverse Battery

The MC33288 is self protected against reverse battery up to -14 V in a continuous mode. When a negative battery voltage arises, the MOSFETs are internally turned off. The load current flows in the body diode of each MOSFET. The power dissipation within the MC33288DH is then V_F x I_{LOAD}, where I_{LOAD} is the total current set by the loads and V_F is the forward body diode voltage. V_F is 0.5 V typical at 150°C and decreases with temperature with a drop of -2.0 mV/°C.

Power Output Switches

The device has two independent high-side switches. Each switch is realized with an N-channel power MOSFET and includes current and temperature sensing circuitries. The MOSFET gates are driven by analog circuitry which includes charge pump and fault detection. A specific feature of this device is the output current recopy.

Each output has a 25 mΩ R_{DSON} maximum at 25°C. The R_{DSON} value reaches 40 mΩ at 150°C junction temperature. Each output has a parasitic drain to source diode, inherent to the technology. This diode can sustain as much current as the MOSFET. This diode is reversed biased during normal operation of the MOSFET and is forward biased during reverse battery or negative transient pulses.

The output MOSFET can each drive 8.0 A nominal. This maximum current condition occurs when up to three 21 W lamps and two small 5.0 W or 7.0 W lamps are connected on each channel, at higher V_{BAT} voltage specification. This is the case when a trailor is attached to the car. As the flasher can operate in warning or hazard operation mode with its two channels on, the MC33288 can drive 16 A total.

When lamps are turned on, the inrush current can reach up to 6 times the nominal lamp current. For this particular application, the total inrush current can reach 6 x 8.0 A–that

is up to 48 A per channel. The 48 A value will only occur at the first lamp turn-on. In order to optimise the total system (MC33288, printed circuit board, wiring, fuse etc.), the device incorporates a current limitation at 30 A typical. This means that the first in rush current will be clamped at 30 A. The second lamp turn-on of the flashing cycle will not see any clamping as the lamps have been heated up in the previous cycle.

IN1 and IN2 are the two inputs of the device, connected to a microcontroller I/O; they are CMOS compatible. When these inputs are in low state, the device is in standby mode. When any of the inputs are switched to a high level, the associated output MOSFET is turned on.

Status

The device has a single status terminal which reports an overtemperature and an openload condition in the device. This terminal is an open drain structure and needs an external pull-up resistor. The device incorporates overtemperature sense on each output MOSFET in order to independently protect each output. But, the report of the overtemperature is done through one single status terminal, called STATUS, in order to minimize the number of I/O connections of the MCU.

Open Load Function

The open load detection is active during the ON phase (hot openload detection). An amplifier measures the differential voltage between V_{BAT} and V_{OUT}.

When the load current is below 1.0 A, the openload circuitry will pull down the status output. If the openload condition is present before the device turn-on, the status will be pulled down after a delay due to the rise time of the output.

Current Recopy Function

Flasher application needs to detect failed lamp. The system must detect one 21 W lamp failing, in the flasher application only, without a trailor. The MC33288 has an output current recopy function which recopies on the CUR R terminal a portion of the output current. Each channel is connected to the same CUR R terminal as the system has to operate in the flasher mode only and not in the warning operation.

The MC33288 provides a current recopy of 1/1000 of the main output current, either output left or right. The recopy function has its higher accuracy of ±10% in the usual operation range and an accuracy of ±20% in the total operating range. This allows a precise detection of one 21 W lamp, but also the detection of additional lamps in case of trailor connection.

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An external resistor must be connected to the CUR R terminal and then tied to a microcontroller A/D input for analog voltage measurement. The CUR R terminal is internally clamped to protect the MCU A/D input.

Warning Lamp Driver

The warning lamp driver is a 3.2 Ω R_{DSON} maximum high-side MOSFET to control the 1.2 W dashboard warning lamp. This output is current limited and thermally protected-activated only in the warning mode. It is turned on by activation of both right and left inputs (IN1 and IN2).

Package

The device is assembled into a power surface mount package. This package offers high thermal performances and high current capabilities. It offers 10 terminals on each package sides and an additional terminal which is the package heat sink , called terminal 21. The heak sink acts as the MC33288 power V_{BAT} connection.

Soldering Information

This device is packaged in a Surface Mount Power package indended to be soldered directly on the Printed Circuit Board.

This device was qualified according to JEDEC standards JESD22-A113-B and J-STD-020A with the reflow conditions applicable for packages with thickness above 2.5 mm:

Convection 220°C +5/-0°C

VPR 215-219°C

IR / Convection 220°C +5/-0°C

The maximum peak temperature during the soldering process should not exceed 220°C (+5°C/-0°C). The time at maximum temperature should range from 10 to 40s maximum.

Thermal Management

The junction to case thermal resistance is 2°C/W maximum. The junction to ambient thermal resistance is dependent on the mounting technology and the addition of heat sink. One of the most commonly used mounting techniques consists of using the printed circuit board and the copper lines as heat sink.
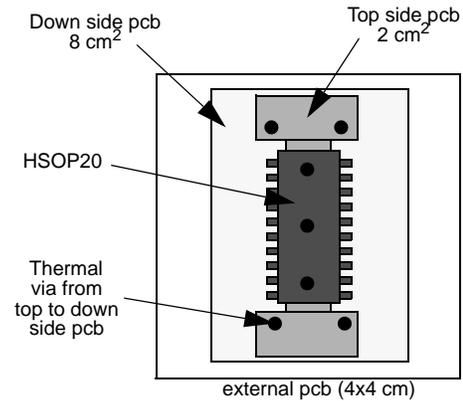
Figure 3. Printed Board Layout Example (not to scale)

Figure 1 shows an example of printed circuit board layout. It has a total of 10 cm^2 additional copper on two sides (2.5 cm^2 on the top side and 7.5 cm^2 on the down side).

With the above layout, thermal resistance junction to ambient of 25°C/W can be achieved, this value being split into:

- junction to case : $R_{\theta JC1}$ = $R_{\theta JC2}$ = 2°C/W
- case to ambient : $R_{\theta CA}$ = 23°C/W

Lower value can be reached with the help of larger and thicker copper metal, higher number of thermal via from top to down side pcb and the use of additional thermal via from the circuit board to the module case.

Steady State Thermal Model

The junction to ambient thermal resistance of the circuit mounted on a printed circuit board can be split into two main parts: junction to case and case to ambient resistances.
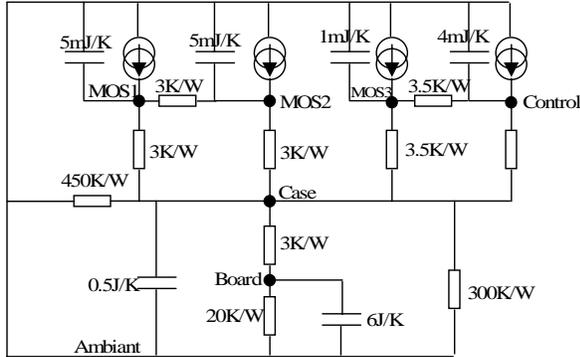
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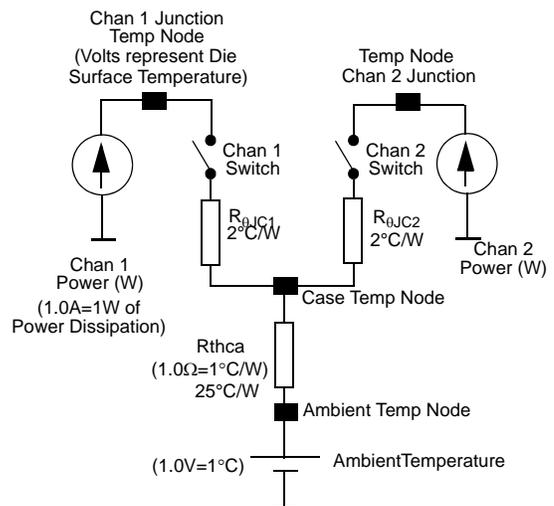
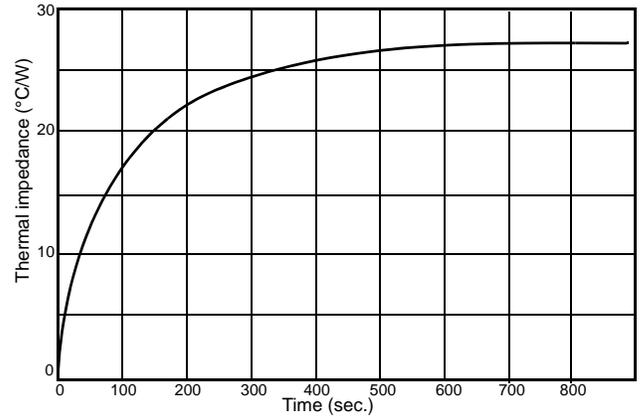**Figure 4. Simplified Thermal Model (Electrical Equivalent)**

33288

Transient Thermal Model

A more complete model including thermal capacitance is proposed in Figure 3.

Figure 5. Transient Thermal Model

This gives a thermal impedance versus time (Figure 4), which has been determined with the printed circuit board shown in Figure 1.

Figure 6. Junction to Ambiant Thermal Impedance

This figure shows that the steady state is reached after about 10 minutes. It also clearly shows that the device can dissipate almost twice the power within one minute compared to the maximum allowed power dissipation in steady state.

TYPICAL APPLICATIONS
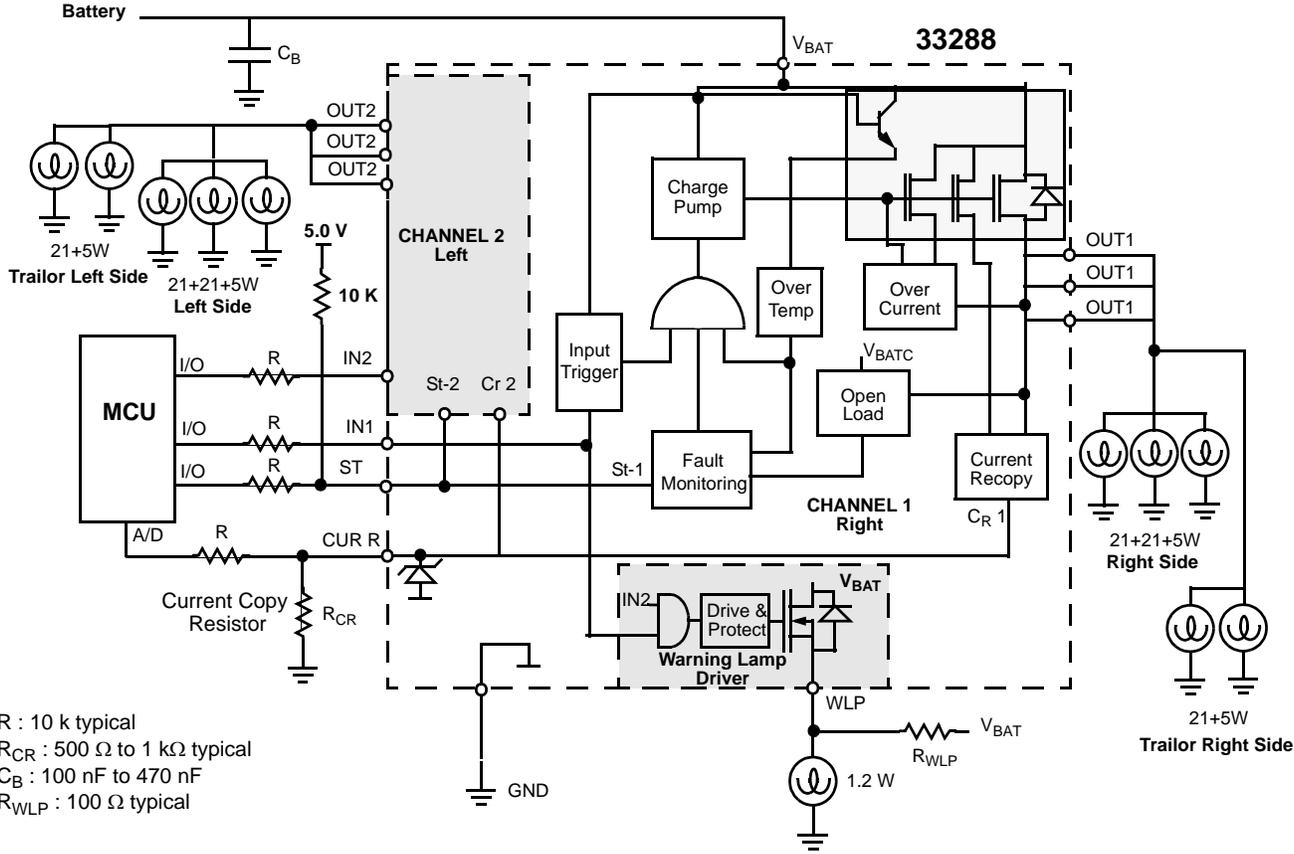
Figure 7. Typical Application - Automotive Flasher

PACKAGING

PACKAGING INFORMATION

DH SUFFIX
20-LEAD HSOP
PLASTIC PACKAGE
98ASH70273A
ISSUE C

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TITLE: 20 LEAD HSOP	DOCUMENT NO: 98ASH70273A	REV: E
	CASE NUMBER: 979-04	19 MAY 2005
	STANDARD: NON-JEDEC	

33288

PACKAGING INFORMATION (CONTINUED)

DH SUFFIX
20-LEAD HSOP
PLASTIC PACKAGE
98ASH70273A
ISSUE C

EXPOSED HEATSINK
AREA

7.200
7.000

12.470
12.270

2.900
2.700

BOTTOM VIEW

0.482
0.400

0.310
0.230

0.280
0.230

△5
0.520
0.400

⊕ 0.200 Ⓜ C A

SECTION "W—W"

0.350

W

W

⬡ 0.100 C

8°
0°

1.100
0.840

(1.600)

GAUGE
PLANE

⊕ 0.100 D

D

0.050

DETAIL "Y"

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| | STANDARD: NON−JEDEC | |

33288

REVISION HISTORY

REVISION	DATE	DESCRIPTION OF CHANGES
6.0	5/2005	• Implemed Revision History page • Changed Part Number MC33288DH to MC33288DDH - Noelectrical changes.

How to Reach Us:

Home Page:
www.freescale.com

E-mail:
support@freescale.com

USA/Europe or Locations Not Listed:
Freescale Semiconductor
Technical Information Center, CH370
1300 N. Alma School Road
Chandler, Arizona 85224
+1-800-521-6274 or +1-480-768-2130
support@freescale.com

Europe, Middle East, and Africa:
Freescale Halbleiter Deutschland GmbH
Technical Information Center
Schatzbogen 7
81829 Muenchen, Germany
+44 1296 380 456 (English)
+46 8 52200080 (English)
+49 89 92103 559 (German)
+33 1 69 35 48 48 (French)
support@freescale.com

Japan:
Freescale Semiconductor Japan Ltd.
Headquarters
ARCO Tower 15F
1-8-1, Shimo-Meguro, Meguro-ku,
Tokyo 153-0064
Japan
0120 191014 or +81 3 5437 9125
support.japan@freescale.com

Asia/Pacific:
Freescale Semiconductor Hong Kong Ltd.
Technical Information Center
2 Dai King Street
Tai Po Industrial Estate
Tai Po, N.T., Hong Kong
+800 2666 8080
support.asia@freescale.com

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