



MOTOROLA **Freescale Semiconductor, Inc.**

MC33186

Automotive H-Bridge Driver

- Operating Supply Voltage 5V to 28V
- Overvoltage Protection against Transients up to 40V at Vbat
- $R_{DSon} = 150m\Omega$ for each Output Transistor at 25°C
- Continuous DC Load Current 5A (TC < 100°C)
- Output Current Limitation at typ 6,5A +/- 20%
- Short-Circuit Shutdown for Output Currents over 8A
- Logic Inputs TTL/CMOS Compatible
- Operating Frequency up to 20 kHz
- Overtemperature Protection
- Short-Circuit Protection
- Undervoltage Disable Function
- Diagnostic Output
- 2 Disable Inputs
- Coding Input for Alternative Functions
- HSOP20 Power Package
- Stable Operation with an External Capacitance of maximum 47 μ F at Vbat

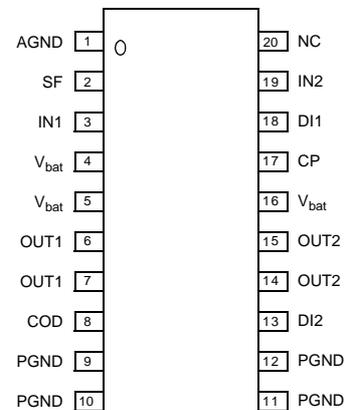
H-BRIDGE DRIVER

**SEMICONDUCTOR
TECHNICAL DATA**



DH1 SUFFIX
PLASTIC PACKAGE
CASE 751A-03
HSOP-20

PIN CONNECTIONS



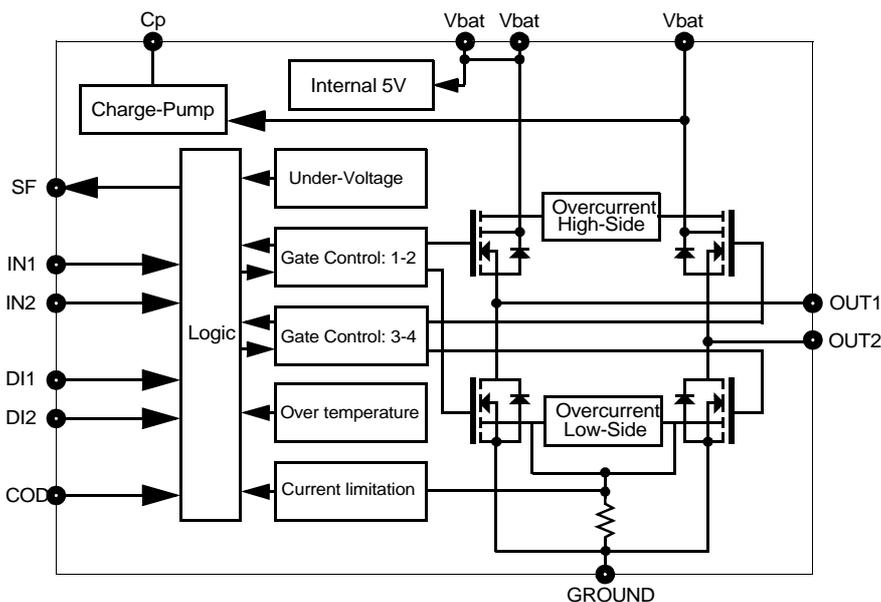
Metal slug is connected to power ground

(Top View)

ORDERING INFORMATION

| Device | Temperature Range | Package |
|--------------|-------------------|---------|
| MC33186DH1R2 | -40°C to +125°C | HSOP20 |

Simplified Block Diagram



**For More Information On This Product,
Go to: www.freescale.com**

MAXIMUM RATINGS

| Ratings | Symbol | Min | Typ | Max | Unit |
|---------|--------|-----|-----|-----|------|
|---------|--------|-----|-----|-----|------|

ELECTRICAL RATINGS

| | | | | | |
|--|-----------------|------------|--|----------|---|
| Supply Voltage - Static Destruction Proof - Dynamic Destruction Proof $t < 0,5s$ | Vbat Vbat | - 1 - 2 | | 28 40 | V |
| Logic Inputs (IN1, IN2, DI1, DI2, CODE) | U | - 0.5 | | 7 | V |
| Output Status - Flag SF | U _{SF} | - 0.5 | | 7 | V |

THERMAL RATINGS

| | | | | | |
|--|-------------------|------|--|------|-----|
| Junction Temperature | T _j | - 40 | | +150 | °C |
| Storage Temperature | T _s | - 55 | | +125 | °C |
| Ambient Temperature | T _a | - 40 | | +125 | °C |
| Thermal Resistance (with power applied on 2 power MOS) | Rth _{JC} | | | +1,5 | K/W |

ELECTRICAL CHARACTERISTICS. T_j : from -40°C to +150 °C, Vbat from 5 V to 28 V, unless otherwise note. Typical values reflect approximate mean at 25°C, nominal VCC, at time of device characterization.

| Characteristics | Symbol | Min | Typ | Max | Unit |
|-----------------|--------|-----|-----|-----|------|
|-----------------|--------|-----|-----|-----|------|

RANGE OF VALIDITY

| | | | | | |
|--|------------------------|----------|--|-----------|---------|
| | Vbat T _j | 5 -40 | | 28 150 | V °C |
|--|------------------------|----------|--|-----------|---------|

POWER SUPPLY

| | | | | | |
|---|--------------|--------------------|-------------|-----------|--------------|
| Operating Range : - Static - Dynamic (t < 500ms) | Vbat Vbat | 5 | | 28 40 | V V |
| Standby current - f = 0 to 10KHz ; I _{OUT} = 0A | I Vbat | | | 35 | mA |
| Vbat-undervoltage switch-off (without load) - Switch-off Voltage - Switch-on Voltage - Hysteresis | | 4.15 4.5 150 | 4.4 4.75 | 4.65 5 | V V mV |

CHARGE-PUMP SUPPLY

| | | | | | |
|---------------------------------|--------------------------|------|--|----|--------|
| - Vbat = 4.15 V - Vbat < 40V | Vcp - Vbat Vcp - Vbat | 3.35 | | 20 | V V |
|---------------------------------|--------------------------|------|--|----|--------|

LOGIC INPUTS

| | | | | | |
|---|------------------|-------|------|-----|----|
| Input High | VinH | 3.4 | | | V |
| Input Low | VinL | | | 1.4 | V |
| Input Hysteresis | U | 0.7 | 1 | | V |
| Input Current (IN1, IN2, DI1) - U _{IN} = 0V | I | - 200 | - 80 | | μA |
| Input Current (DI2,COD) - U _{DI2} = 5V | I _{DI2} | | 25 | 100 | μA |

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ELECTRICAL CHARACTERISTICS. T_j: from -40°C to +150 °C, V_{bat} from 5 V to 28 V, unless otherwise note. Typical values reflect approximate mean at 25°C, nominal VCC, at time of device characterization.

| Characteristics | Symbol | Min | Typ | Max | Unit |
|-----------------|--------|-----|-----|-----|------|
|-----------------|--------|-----|-----|-----|------|

POWER OUTPUTS : OUT1, OUT2

| | | | | | |
|--|--|-----------|------|-----------|----------|
| Switch on resistances : R _{OUT} - V _{bat} ; R _{OUT} - GND - V _{bat} = 5 to 28V ; C _{cp} = 0 to 33nF | | | | 300 | mΩ |
| Current Limitation Controlled Peak Value | | | | | |
| Switch-off Current | (I _{OUT}) max | 5.2 | 6.5 | 7.8 | A |
| Switch-off Time | t _a | 15 | 20.5 | 26 | μs |
| Blanking Time | t _b | 12 | 16.5 | 21 | μs |
| High Side Overcurrent Detection Low Side Overcurrent Detection (4) | I _{OCHS} I _{OCLS} | 11 8 | | | A A |
| Leackage Current - Output Stage Switched off | | | | 100 | μA |
| Free-Wheeling Diode Forward Voltage - I _{OU} = 3A | U _D | | | 2 | V |
| Free-Wheeling Diode Reverse Recovery Time | t _{rr} | 100 | | | ns |
| - Switch-off Temperature - Hysteresis | | 160 20 | | 190 30 | °C °C |

OUTPUT STATUS FLAG (Open drain output)

| | | | | | |
|--|-----------------|--|--|----|----|
| Output High (SF not set) U _{SF} = 5V | I _{SF} | | | 10 | μA |
| Output Low (SF set) ISF = 300 μA | V _{SF} | | | 1 | V |

TIMING

| | | | | | |
|--|---------------------------------|---|---|----|-----|
| PWM frequency - C _{CP} = 33nF | f | | | 10 | KHz |
| Maximum Switching Frequency During Current Limitation - V _{bat} = 6.....28V.....C _{CP} = 33nF | f | | | 20 | KHz |
| Output ON Delay IN1>OUT1 or IN2.....>OUT2 | t _{don} | | | 15 | μs |
| Output OFF Delay IN1>OUT1 or IN2.....>OUT2 | t _{doff} | | | 15 | μs |
| Output Switching Time - C _{CP} = 0 to 33nF OUTiHOUTiL, OUTiLOUTiH, I _{OUT} = 3A | t _r , t _f | 2 | | 5 | μs |
| Disable Delay Time DIiOUTi | t _{ddis} | | | 8 | μs |
| Turn off in Case of Over-current or Over-temperature | | | 4 | | μs |
| Power On Delay Time (C _{cp} = 33nF) | | | 1 | 5 | ms |

Freescale Semiconductor, Inc.**TRU TABLE**

| Device State | Input Conditions | | | | Status | | Outputs | |
|-------------------------|------------------|------------|-----|-----|-----------|-----------|---------|-----|
| | DI1 (3) | DI2 (3) | IN1 | IN2 | SF (5) | SF (6) | OU1 | OU2 |
| 1-Forward | L | H | H | L | H | H | H | L |
| 2-Reverse | L | H | L | H | H | H | L | H |
| 3-Free Wheeling Low | L | H | L | L | H | H | L | L |
| 4-Free Wheeling High | L | H | H | H | H | H | H | H |
| 5-Disable 1 | H | X | X | X | L | H | Z | Z |
| 6-Disable 2 | X | L | X | X | L | H | Z | Z |
| 7-IN1 Disconnected | L | H | Z | X | H | H | H | X |
| 8-IN2 Disconnected | L | H | X | Z | H | H | X | H |
| 9-DI1 Disconnected | Z | X | X | X | L | H | Z | Z |
| 10-DI2 Disconnected | X | Z | X | X | L | H | Z | Z |
| 11-Current Limit.active | L | H | X | X | H | H | Z | Z |
| 12-Undervoltage (1) | X | X | X | X | L | L | Z | Z |
| 13-Over-temperature (2) | X | X | X | X | L | L | Z | Z |
| 14-Over-current (2) | X | X | X | X | L | L | Z | Z |

NOTE :

(1) In case of undervoltage, tristate and status-flag are reset automatically.

(2) Whenever over-current or over-temperature is detected, the fault is stored (i.e.status-flag remains low).

The tristate conditions and the status-flag are reset via DI1 (IN1) or DI2 (IN2).

Pinnames in brackets refer to coding pin (COD=Vcc).

(3) If COD = Vcc then DI1 and DI2 are not active.

(4) In case of over-current, the time when the current is greater than 7,8A is lower than 30µs, with a maximum frequency of 1kHz.

(5) COD=nc or GND

(6) COD = VCC

L = Low

H = High

X = High or Low

Z = High impedance (all output stage transistors are switched off).

| Pin | Name | Description |
|-----------------------------|--------------------------------|--|
| 9, 10, 11, 12 Metal slug | GND | Power Ground |
| 1 | GND | Analog ground |
| 2 | Output Status-flag (SF) | Open drain output, active low. Is set according to the truth table . |
| 3,13 18, 19 | Inputs IN1,IN2 DI1,DI2, COD | Voltage controlled inputs with hysteresis |
| 8 | COD | When not connected or connected to GND, a stored failure will be reset by change of the voltage-level on DI1 or DI2. When connected to Vcc, the disable pin DI1 and DI2 are inactive. A stored failure will be reset by change of the voltage-level on IN1 or IN2 . |
| 6, 7, 14, 15 | OUT1 , OUT2 | H-Bridge outputs with integrated free-wheeling diodes. |
| 4, 5, 16 | Vbat | <p>The pins 4 and 5 are internally connected. These pins supply the left high side and the analogue/logic part of the device. The pin 16 supplies the right high side and the charge pump. The pins 4, 5 and 16 should be connected together on the printed circuit board with connections as short as possible.</p> <p><i>Supervision and protection functions</i></p> <p><i>a) Supply voltage supervision</i> The supply voltage is supervised . If it is below its specific threshold , the power stages are switched in tristate and the status flag is switched low. If the supply voltage is over the specific threshold again , the power stage switches independently into normal operation, according to the input pins and the status flag is reset .</p> <p><i>b) Thermal supervision</i> In case of over-temperature the power stages are switched in tristate independent of the inputs signals and the status flag is switched low. If the level changes from high to low on DI1 (IN1) or low to high on DI2 (IN2), the output stage switches on again if the temperature is below the specified limit .The status-flag is reset to high level (Pinnames in brackets refer to coding pin=Vcc).</p> <p><i>c) Supervision of overcurrent</i> If overcurrent is detected the power stages are independent of the inputs signals switched in tristate and the status flag is set . If the level changes from high to low on DI1 (IN1) or low to high on DI2 (IN2) the output stage switches on again and the status flag is reset to high level (Pinnames in brackets refer to coding pin = Vcc). The output stage switches into the mode defined by the inputs pins provided the temperature is below the specified limits .</p> <p><i>d) Current limiting</i> The maximum current which can flow under normal operating conditions is limited to $I_{max} = 6,5A \pm 20\%$.When the maximum current value is reached, the output stages are switched tristate for a fixed time. According to the time constant the current decreases until the next switch on occurs. See page 8 for schematics.</p> |

Figure 1. Typical Application

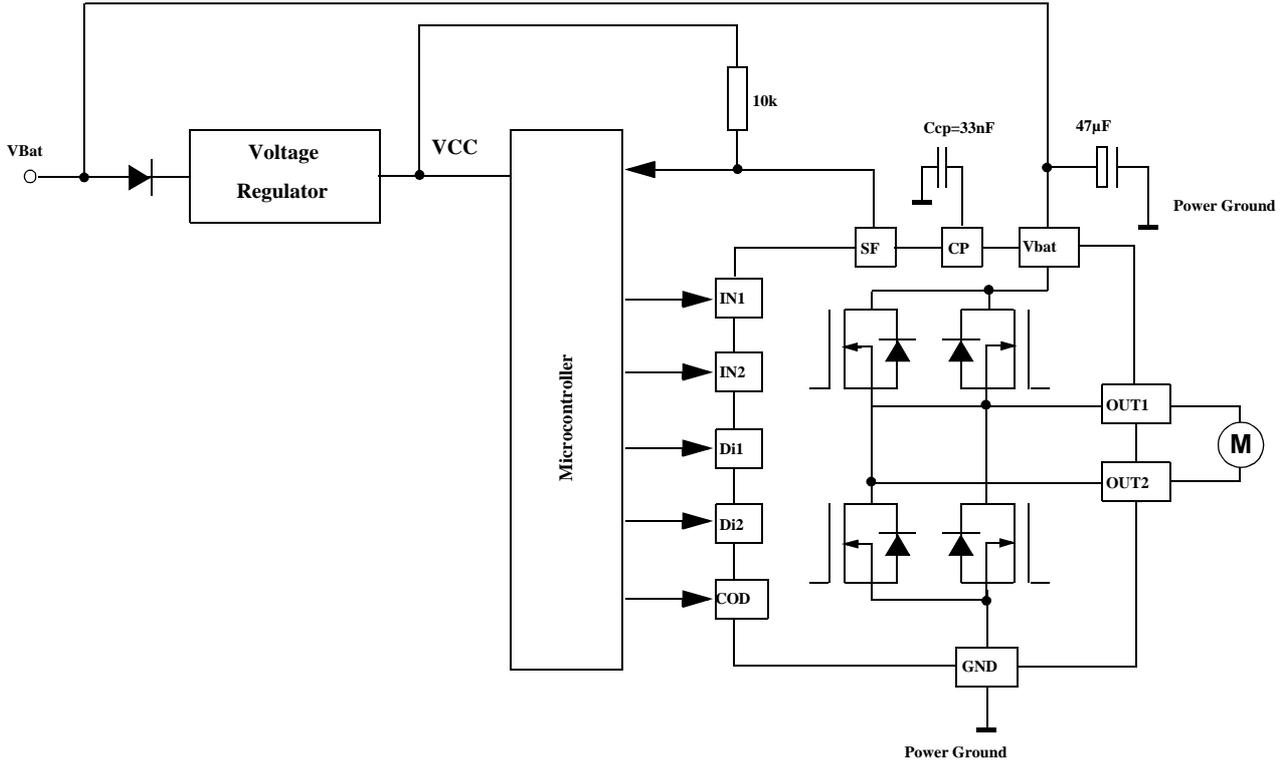


Figure 2. Output delay time

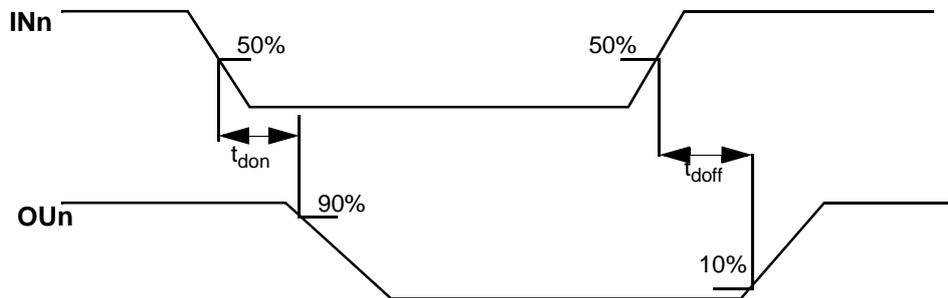
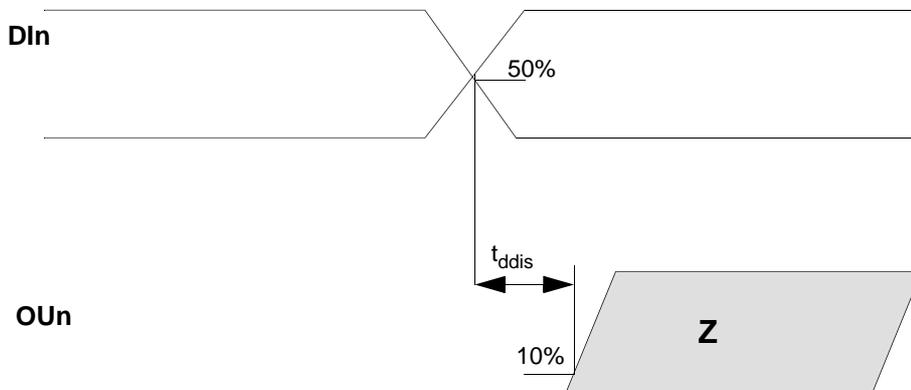


Figure 3. Disable Delay Time



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Figure 4. Output Switching Time

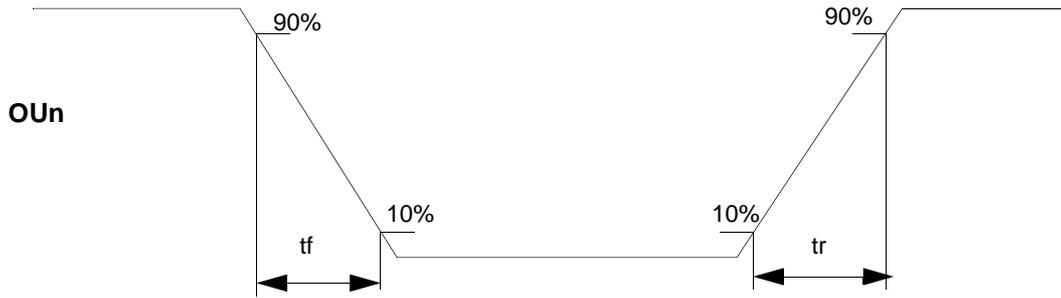


Figure 5. Current Limitation

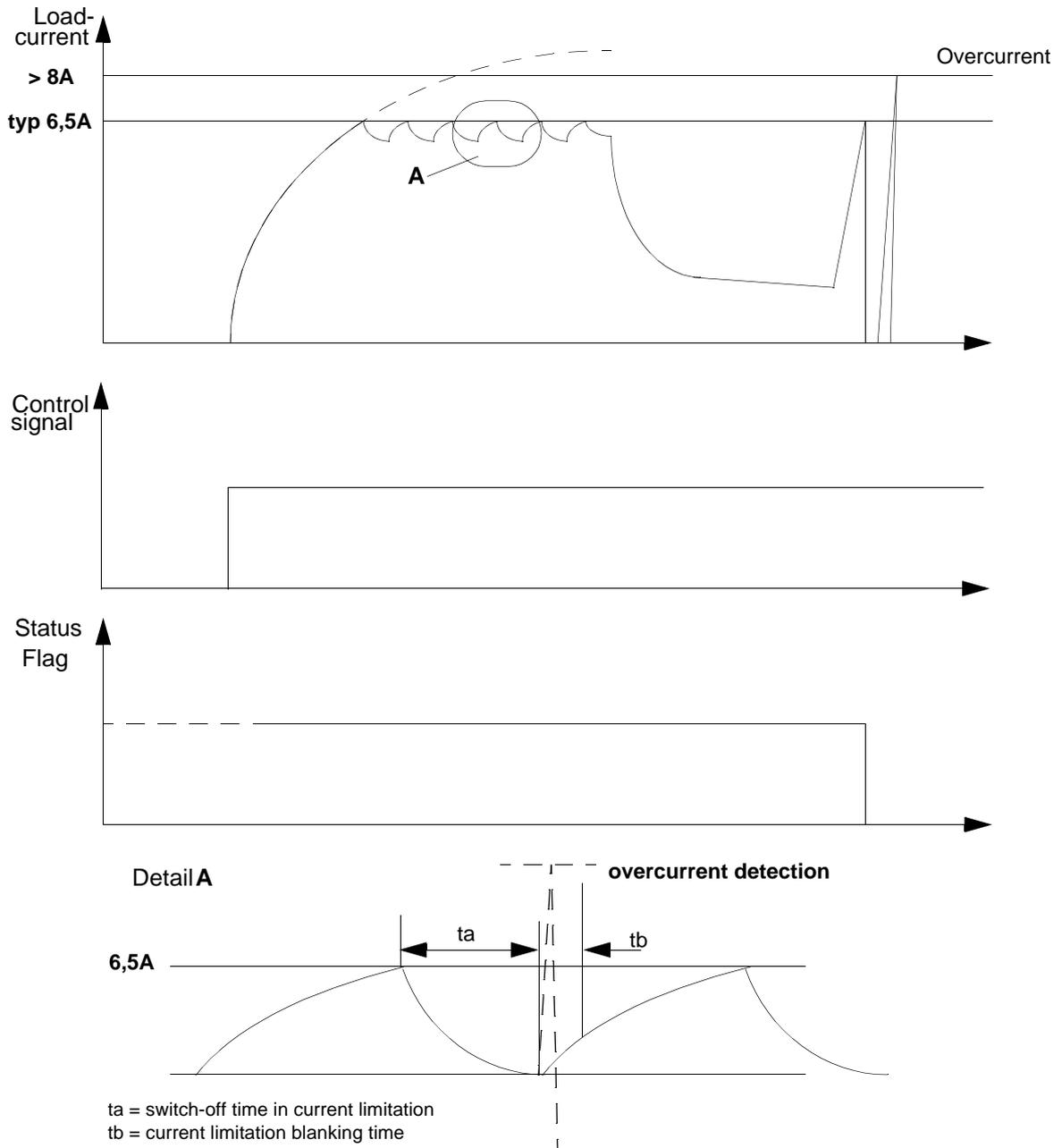


Figure 6 - Standby Current versus Temperature

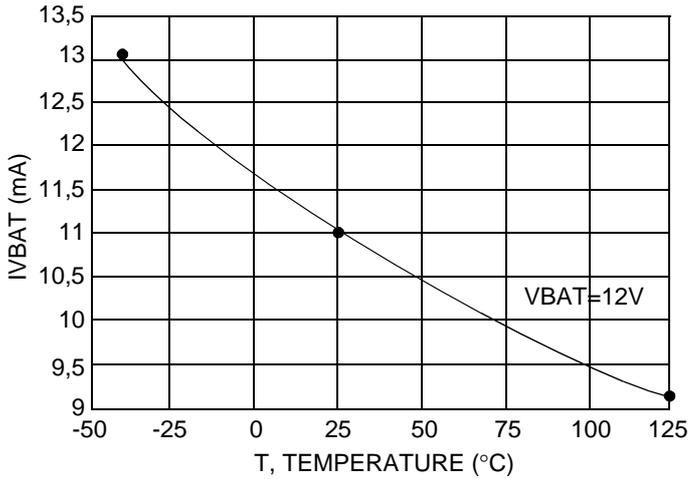


Figure 7. VBAT Undervoltage versus Temperature

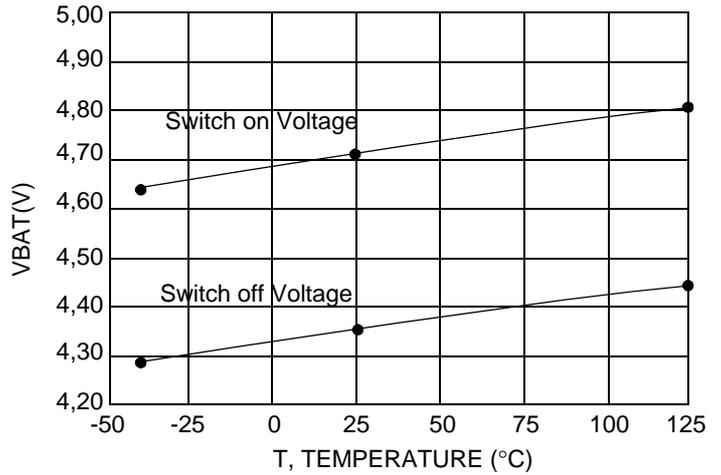


Figure 8 - Low Threshold Input Voltage versus Temperature

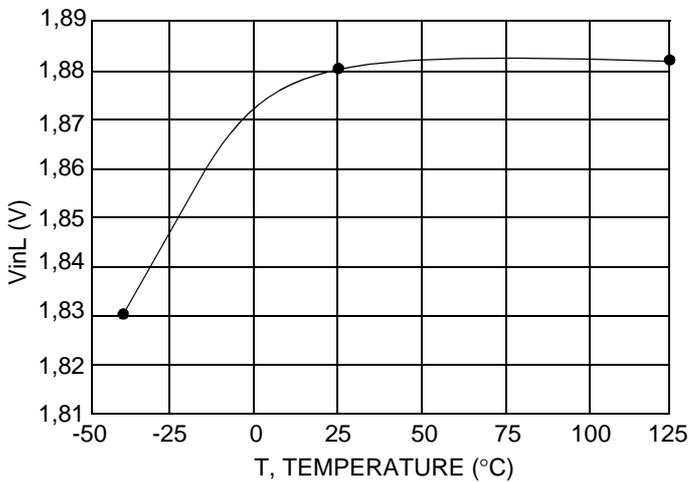


Figure 9 - High Threshold Input Voltage versus Temperature

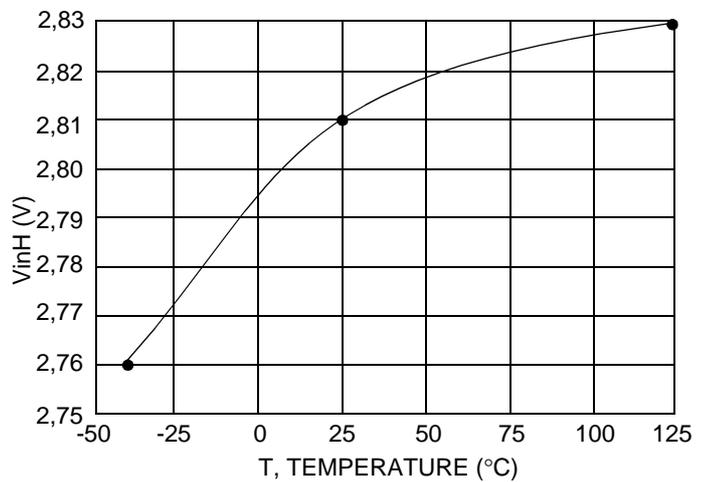


Figure 10 - Vcp versus Battery Voltage

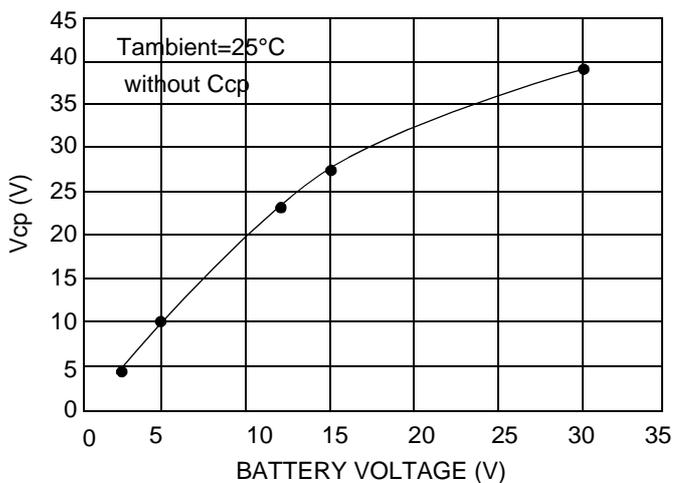
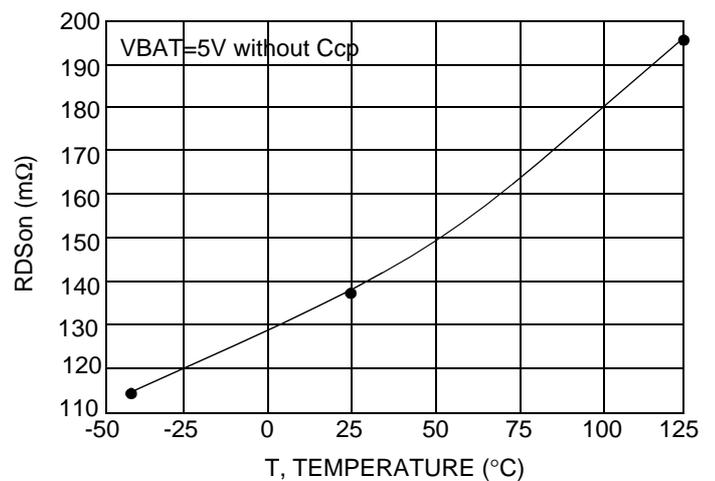


Figure 11. RDSON versus Temperature



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Figure 12. Switch off current versus Temperature

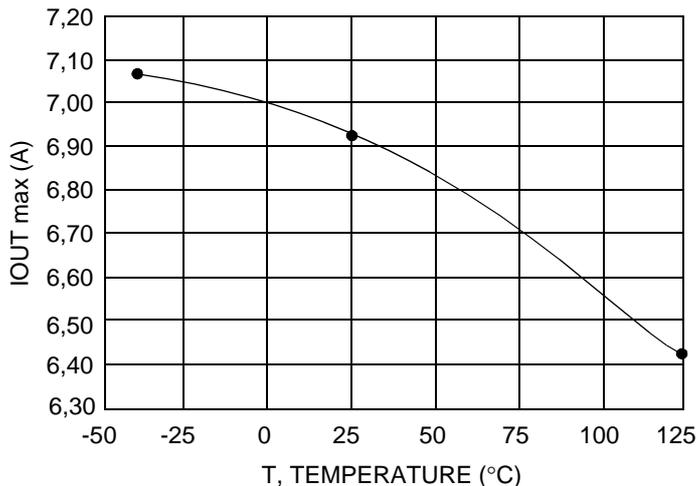


Figure 13. Over Current Detection versus Temperature

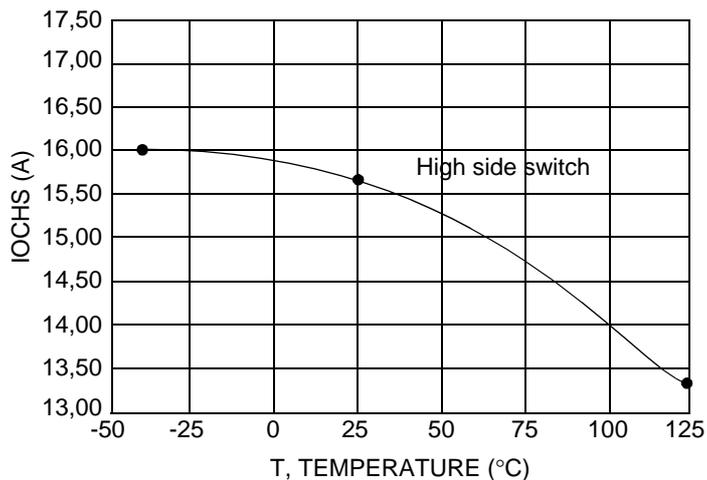


Figure 14. Current Limitation

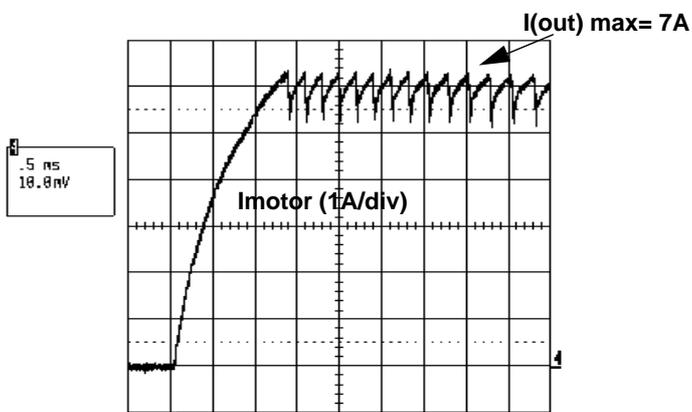


Figure 15. Switch off Time

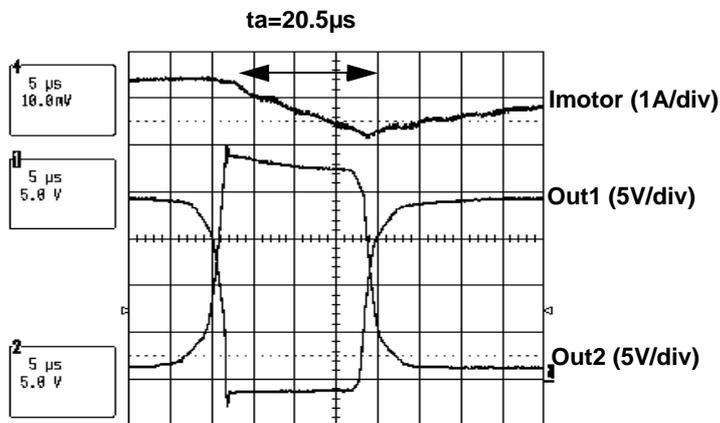


Figure 16. Output Switching Time: Tr

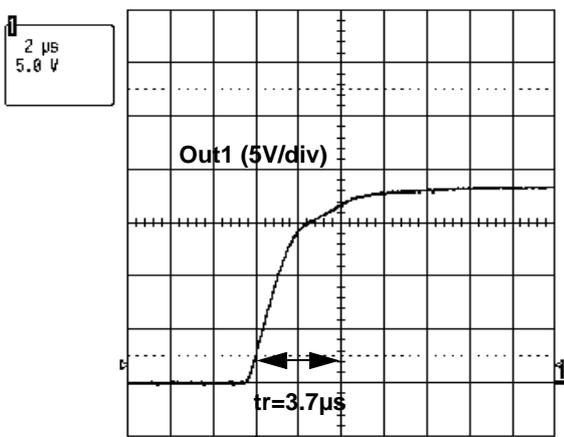
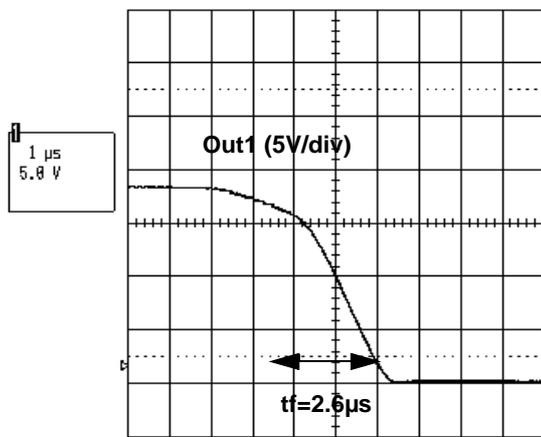


Figure 17. Output Switching Time: Tf



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Figure 18. Output OFF Delay

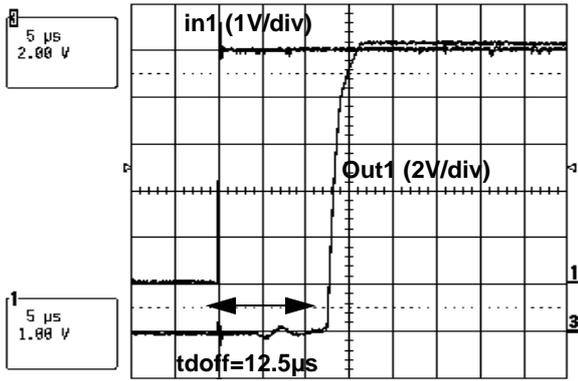


Figure 19. Output ON Delay

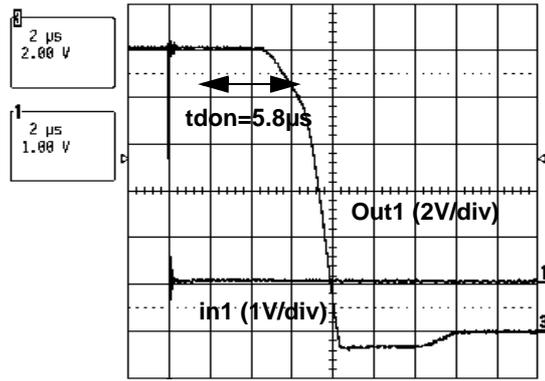


Figure 20. Disable Delay Time

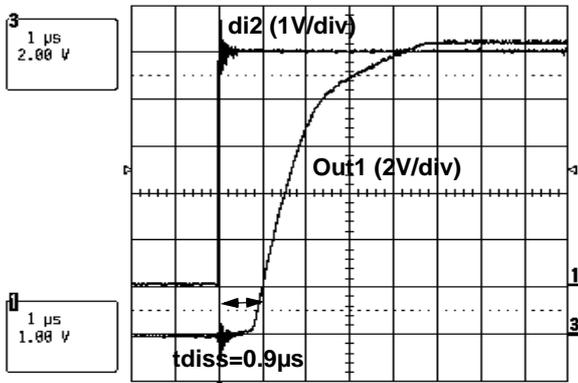
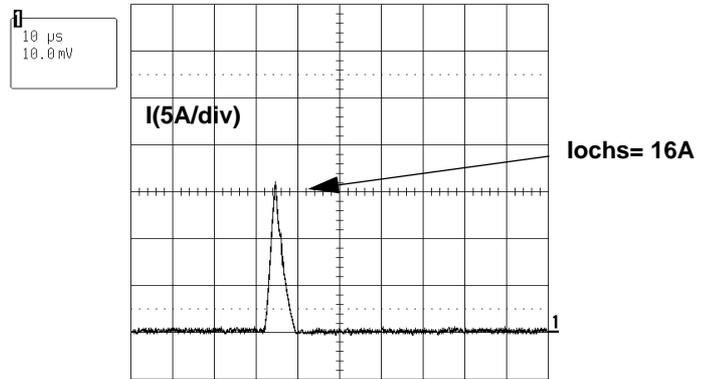


Figure 21. High side Overcurrent Detection



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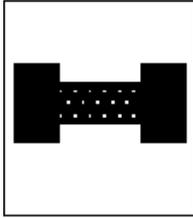
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The HSOP20 package is designed for enhanced thermal performance. The particularity of this package is its copper baseplate on which the power die is soldered. The baseplate is soldered on a PCB to provide heat flow to the ambient and also to provide a large thermal capacitance.

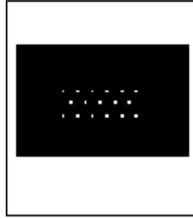
Of course, the more copper area on the PCB, the better the power dissipation and transient behaviour.

We characterized the HSOP20 on a double side PCB. The bottom side area of the copper is 7.8 cm². The top surface is 2.7 cm², see Figure 22.

Figure 22. PCB Test Layout



Top Side



Bottom Side

Figure 23. PHSOP20 Thermal Response

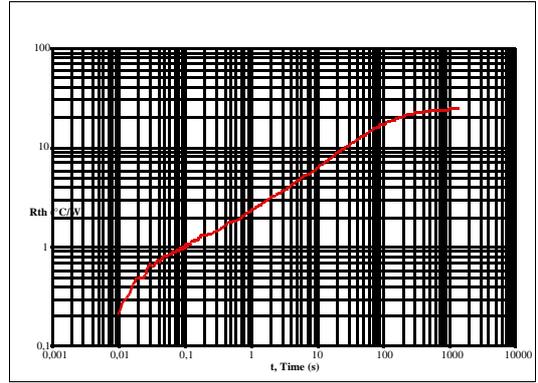
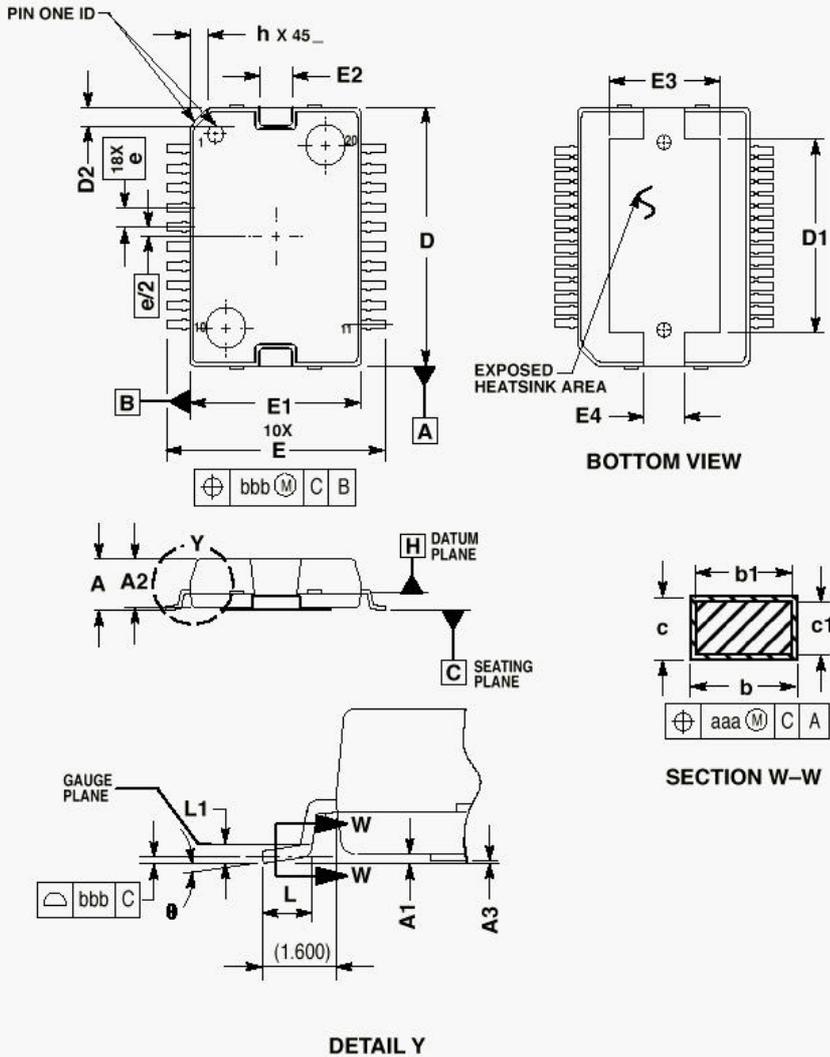


Figure 23 shows the thermal response with the device soldered on to the test PCB described on figure 22.



NOTES:

1. CONTROLLING DIMENSION: MILLIMETER.
2. DIMENSIONS AND TOLERANCES PER ASME Y14.5M, 1994.
3. DATUM PLANE -H- IS LOCATED AT BOTTOM OF LEAD AND IS COINCIDENT WITH THE LEAD WHERE THE LEAD EXITS THE PLASTIC BODY AT THE BOTTOM OF THE PARTING LINE.
4. DIMENSIONS D AND E1 DO NOT INCLUDE MOLD PROTRUSION. ALLOWABLE PROTRUSION IS 0.150 PER SIDE. DIMENSIONS D AND E1 DO INCLUDE MOLD MISMATCH AND ARE DETERMINED AT DATUM PLANE -H-.
5. DIMENSION b DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.127 TOTAL IN EXCESS OF THE b DIMENSION AT MAXIMUM MATERIAL CONDITION.
6. DATUMS -A- AND -B- TO BE DETERMINED AT DATUM PLANE -H-.
7. DIMENSION D DOES NOT INCLUDE TIEBAR PROTRUSIONS. ALLOWABLE TIEBAR PROTRUSIONS ARE 0.150 PER SIDE.

| DIM | MILLIMETERS | |
|-----|-------------|--------|
| | MIN | MAX |
| A | 3.000 | 3.400 |
| A1 | 0.100 | 0.300 |
| A2 | 2.900 | 3.100 |
| A3 | 0.00 | 0.100 |
| D | 15.800 | 16.000 |
| D1 | 11.700 | 12.600 |
| D2 | 0.900 | 1.100 |
| E | 13.950 | 14.450 |
| E1 | 10.900 | 11.100 |
| E2 | 2.500 | 2.700 |
| E3 | 6.400 | 7.200 |
| E4 | 2.700 | 2.900 |
| L | 0.840 | 1.100 |
| L1 | 0.350 BSC | |
| b | 0.400 | 0.520 |
| b1 | 0.400 | 0.482 |
| c | 0.230 | 0.320 |
| c1 | 0.230 | 0.280 |
| e | 1.270 BSC | |
| h | 1.100 | |
| Ø | 0 | 8 |
| aaa | 0.200 | |
| bbb | 0.100 | |

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