Thermal Data for Avago Optocouplers

Application Note 1087

Introduction

This document contains steady state thermal models for optocouplers based on empirical data and theoretical extrapolation.

Seven thermal models have been chosen to suit the type of optocoupler:

- Thermal Model-A for a hermetic-package optocoupler
- Thermal Model-B for a single-channel plastic-package optocoupler
- Thermal Model-C for a single-channel HCPL-3700/60 optocoupler with input buffer circuit
- Thermal Model-D for a dual-channel plastic-package optocoupler
- Thermal Model-E for a single-channel optocoupler with input buffer circuit
- Thermal Model-F for a single-channel SO-5 plastic-package optocoupler
- Thermal Model-G for a dual-channel SO-16 plastic-package optocoupler
- Thermal Model-H for a quad-channel SO-16 plastic-package optocoupler
- Thermal Model-I for a dual-channel bi-directional SO-8 plastic-package optocoupler
- Thermal Model-J for a single-channel SO-4 plastic package solid state relay.

The thermal data in each of these models allows the user to calculate the approximate junction temperatures at various nodes in the optocoupler. The actual semiconductor junction temperatures may vary based upon the heat flows from the surrounding components on the printed circuit board. Each of the models assumes that the optocoupler is either soldered to a printed circuit board (PCB) or placed in a socket, which is soldered on a PCB. The PCB is further assumed to be in still air. In models that define the optocoupler case to be a node, the case-to-ambient thermal resistance will depend on the board design and the placement of the optocoupler. The package case temperature is measured at the center of the package bottom.

The data presented in each of these models is approximate and is meant to be an indicator, not a specification. To ensure reliability, the semiconductor junction temperatures in plastic-package optocouplers must not exceed 125 °C, in R^2Couplers (ACPL-xxxU, ACPL-xxxT) it must not exceed 150 °C, and in hermetic-package optocouplers it must not exceed 175 °C unless otherwise specified.

All thermal data in this document are taken from testing on Avago Technologies devices. They are not transferable to other manufacturers' part types.

Table 1. Optocoupler Thermal Model Index.

Part Number	Thermal Model Type	Comments
4N45/6	Model-B	Approximates 6N138 data
4N55	Model-A	
6N134	Model-A	
6N135/6/7/8/9	Model-B	
6N140	Model-A	
ACSL-6210	Model-I	
ACSL-6300	Model-H	Approximates ACSL-6400 data, omit LED4 and IC5
ACSL-6310	Model-H	Approximates ACSL-6400 data, omit LED1 and IC8
ACSL-6400/6410/6420	Model-H	
HCNW135/6/7, HCNW4502/3, HCNW2601/11	Model-B	
HCNW138/9, HCNW4562	Model-B	Approximates HCNW135 data
HCNW2201/4504/4506	Model-B	Approximates HCNW2601 data
HCPL-0452/3, -0500/1, -050L	Model-B	
HCPL-0201/11, -0454, -0466, -0600/01/11, -0708, -060L	Model-B	Approximates HCPL-0600 data
HCPL-0700/1, 070L	Model-B	
HCPL-0530/1/4, -0630/1, -0730/1, -053L, -063L, -073L	Model-D	Approximates HCPL-0738 data
HCPL-0370	Model-E	
HCPL-0738	Model-D	
HCPL-1930/1	Model-A	
HCPL-2200/01/02/11/12/19	Model-B	
HCPL-2231/2	Model-D	Approximates HCPL-2430 data
HCPL-2300	Model-B	Approximates HCPL-2601 data
HCPL-2400/11	Model-B	
HCPL-2430	Model-D	
HCPL-2502/3, -250L	Model-B	Approximates 6N135 data
HCPL-2530/1/3, -253L	Model-D	Approximates HCPL-2430 data
HCPL-2601/11/12, -260L	Model-B	Approximates 6N137 data
HCPL-2630/1, -2730/1, -263L, -273L	Model-D	Approximates HCPL-2430 data
HCPL-3000, 3100/1		Refer to Application Note 1058
HCPL-0302/0314	Model-B	
HCPL-3120/3150/3180		Refer to HCPL-3120/3150/3180 data sheet
HCPL-314J	Model-G	Approximates HCPL-315J data
HCPL-315J	Model-G	
HCPL-316J		Refer to HCPL-316J data sheets
HCPL-3700/3760	Model-C	
HCPL-4100/4200	Model-C	Approximates HCPL-3700 data
HCPL-4502/3/4/6	Model-B	Approximates 6N135 data
HCPL-4534	Model-D	Approximates HCPL-2430 data
HCPL-4562	Model-B	Approximates 6N135 data
HCPL-4661	Model-D	Approximates HCPL-2430 data
HCPL-4701	Model-B	Approximates 6N138 data
HCPL-4731	Model-D	Approximates HCPL-2430 data
HCPL-52XX, -54XX, -55XX, -56XX, -57XX, -62XX, -64XX, -65XX	Model-A	
HCPL-7100/01	Model-E	
HCPL-7710, -7720, -7721, -7723	Model-E	Approximates HCPL-7100 data
HCPL-0710, -0720, -0721, -0723	Model-E	Approximates HCPL-0370 data
HCPL-7601/7611	Model-B	Approximates 6N137 data
HCPL-7800/40, -7510/20,	Model-C	Approximates HCPL-3700 data
HCPL-7860/786J		Refer to HCPL-7860/786J data sheet
HSSR-7110		Refer to HSSR-7110 data sheet
HCPL-M600/601/611	Model-F	
HCPL-M452/3/4/6, -M700/701	Model-F	Approximates HCPL-M600/601/611 data
ASSR-1510	Model-J	

Thermal Model-A for a Hermetic-Package Optocoupler

Definitions

$\theta_{E\text{-}C}$: Thermal resistance from emitter (input LED) junction to package case.

$\theta_{D\text{-}C}$: Thermal resistance from detector (output IC) junction to package case.

$\theta_{C\text{-}A}$: Thermal resistance from package case to ambient. The value $\theta_{C\text{-}A}$ depends on the heat flows from surrounding components, and can be estimated to be in the range of 70 °C/W to 210 °C/W (see Note 5).

Package Case Temperature: Measured at center of package bottom, with no forced air. Ambient Temperature: Measured approximately 15 cm above the package.

Description

This thermal model assumes that an 8- or 16-pin dual-in-line package hermetic optocoupler is inserted into an IC socket, which is soldered into a 7.5 cm x 7.5 cm printed circuit board (PCB). The PCB is suspended in still air.

Thermal resistance values shown in the above figure can be used for calculating the temperatures at each node for a given operating condition. The thermal resistance between the LED and other internal nodes is very large in comparison with the terms shown in the figure, and is omitted for simplicity

For optocouplers that have more than one channel, the same values for $\theta_{E\text{-}C}$ and $\theta_{D\text{-}C}$ can be assumed to be in parallel, as shown by the dotted lines, for each of the additional LED and detector. Again, the direct thermal resistance between any two LEDs, any two detectors, or an LED and a detector is very large in comparison to $\theta_{E\text{-}C}$ and $\theta_{D\text{-}C}$, and may be omitted.

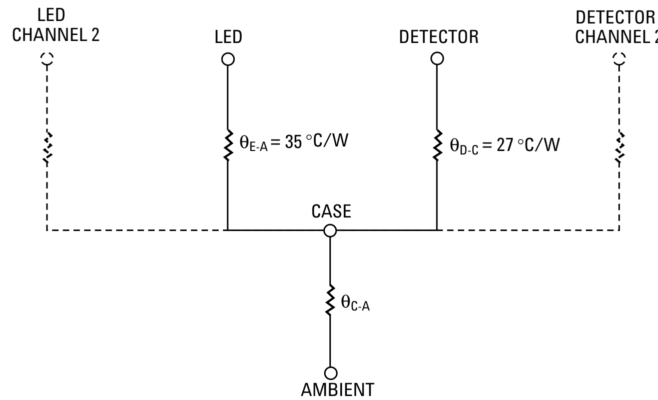


Figure 1. Thermal Model-A Diagram

Notes:
1. Above model is applicable for HCPL-52XX, -54XX, -55XX, -56XX, -57XX, -62XX, 64XX, -65XX, -66XX, -67XX; 4N55; 6N134; and 6N140.
2. For HSSR-7100/1 thermal model, refer to its data sheet.
3. HCPL-193X and HCPL-576X have an input buffer IC. The above model may be used for these optocouplers with an assumption that the Input Buffer IC and LED are a common node. The thermal resistance of this common node to case is approximately 35 °C/W.
4. Maximum Junction Temperature for HSSR-7110/1: 150 °C; for all other hermetic optocouplers: 175 °C.
5. The thermal data in this model assumes the optocoupler is inserted into a socket. Thermal resistance $\theta_{C\text{-}A}$ is likely to be lower when the optocoupler is soldered to a printed circuit board.

Thermal Model-B for a Single-Channel Plastic-Package Optocoupler

Definitions

θ_1: Thermal resistance from LED junction to ambient

θ_2: Thermal resistance from LED to detector (output IC)

θ_3: Thermal resistance from detector (output IC) junction to ambient

Ambient Temperature: Measured approximately 1.25 cm above the optocoupler, with no forced air.

Description

This thermal model assumes that an 8-pin single-channel plastic package optocoupler is soldered into an 8.5 cm x 8.1 cm printed circuit board (PCB). The temperature at the LED and Detector junctions of the optocoupler can be calculated using the equations below.

$\Delta T_{EA} = A_{11}P_E + A_{12}P_D$

$\Delta T_{DA} = A_{21}P_E + A_{22}P_D$

where:

ΔT_{EA} = Temperature difference between ambient and LED

ΔT_{DA} = Temperature difference between ambient and detector

P_E = Power dissipation from LED

P_D = Power dissipation from detector

A_{11}, A_{12}, A_{21}, A_{22} thermal coefficients (units in °C/W) are functions of the thermal resistance θ_1, θ_2, θ_3 (See Note 2).

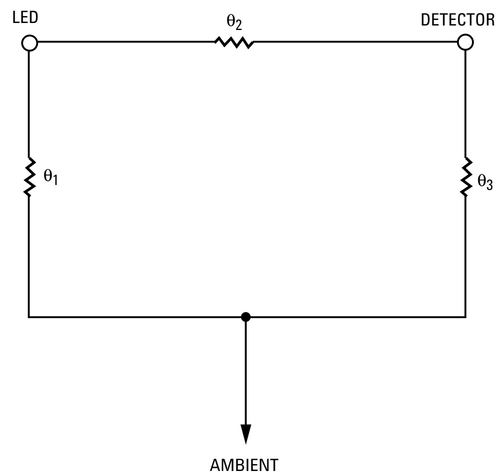


Figure 2. Thermal Model-B Diagram

Table 2. Thermal Model-B Coefficient Data (units in °C/W).

Part Number	A_{11}	A_{12}, A_{21}	A_{22}
6N135/6, HCPL-4503	323	154	225
HCNW135/6, HCNW4502/3	220	61	166
HCPL-0500/1, HCPL-0452/3	409	201	295
HCNW137, HCNW2601/11	219	51	139
HCPL-0600/01/11	455	216	308
HCPL-0700/1	396	193	290
HCPL-2200/01/02/11/12	304	149	216
HCPL-2400/11	337	139	215
HCPL-0302/0314 [3]	334	146	221

Notes:
1. Maximum junction temperature for above parts: 125°C.
2. $A_{11} = \theta_1 \,||\, (\theta_2+\theta_3)$, $A_{12} = A_{21} = (\theta_1\theta_3) / (\theta_1+\theta_2+\theta_3)$, $A_{22} = (\theta_1+\theta_2) \,||\, \theta_3$.
3. The device was mounted on a low conductivity test board as per JEDEC 51-3.

Thermal Model-C for HCPL-3700/60 Optocoupler with Input Buffer Circuit

Definitions

θ1: Thermal resistance from LED/input-buffer IC junctions to ambient

θ2: Thermal resistance from detector IC junction to ambient

Ambient Temperature: Measured approximately 1.25 cm above package, with no forced air.

Description

Thermal resistance values shown in the above figure can be used for calculating the temperatures at each node for a given operating condition. For simplification, the LED and the Input Buffer IC are assumed to be at the same node.

Furthermore, the thermal resistance between the LED and detector are very large in comparison with the terms shown in the figure, and are omitted for simplicity.

$\Delta T_{EA} = \theta_1 P_E$

$\Delta T_{DA} = \theta_2 P_D$

where:

ΔT_{EA} = Temperature difference between ambient and LED

ΔT_{DA} = Temperature difference between ambient and detector

P_E = Power dissipation from LED

P_D = Power dissipation from detector

Note:

1 Maximum junction temperature for above part: 125 °C.

2. Please refer to Thermal Model-E that is simulated with three die.

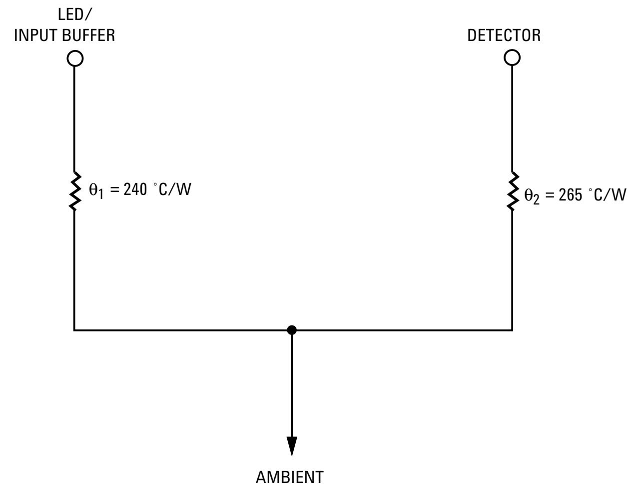


Figure 3. Thermal Model-C Diagram

Thermal Model-D for a Dual-Channel Plastic-Package Optocoupler

Definitions

θ_1, θ_2, θ_3, θ_4, θ_5, θ_6, θ_7, θ_8, θ_9, θ_{10}: Thermal resistances between nodes as shown in Figure 4.

Ambient Temperature: Measured approximately 1.25 cm above the optocoupler HCPLI-2430 with no forced air and 2.54 cm around the optocoupler HCPL-0738 with no forced air.

Description

HCPL-2430 thermal model assumes that an 8-pin dual-channel plastic package optocoupler is soldered into an 8.5 cm x 8.1 cm printed circuit board (PCB). HCPL-0738 thermal model assumes that a SO-8 plastic package optocoupler is soldered into a 7.62 cm x 7.62 cm low K board. These optocouplers are hybrid devices with four die: two LEDs and two detectors. The temperature at the LED and the detector of the optocoupler can be calculated by using the equations below.

$\Delta T_{E1A} = A_{11}P_{E1} + A_{12}P_{E2} + A_{13}P_{D1} + A_{14}P_{D2}$

$\Delta T_{E2A} = A_{21}P_{E1} + A_{22}P_{E2} + A_{23}P_{D1} + A_{24}P_{D2}$

$\Delta T_{D1A} = A_{31}P_{E1} + A_{32}P_{E2} + A_{33}P_{D1} + A_{34}P_{D2}$

$\Delta T_{D2A} = A_{41}P_{E1} + A_{42}P_{E2} + A_{43}P_{D1} + A_{44}P_{D2}$

where:

ΔT_{E1A} = Temperature difference between ambient and LED 1

ΔT_{E2A} = Temperature difference between ambient and LED 2

ΔT_{D1A} = Temperature difference between ambient and detector 1

ΔT_{D2A} = Temperature difference between ambient and detector 2

P_{E1} = Power dissipation from LED 1;

P_{E2} = Power dissipation from LED 2;

P_{D1} = Power dissipation from detector 1;

P_{D2} = Power dissipation from detector 2

A_{XY} thermal coefficient (units in °C/W) is a function of thermal resistances θ_1 through θ_{10}.

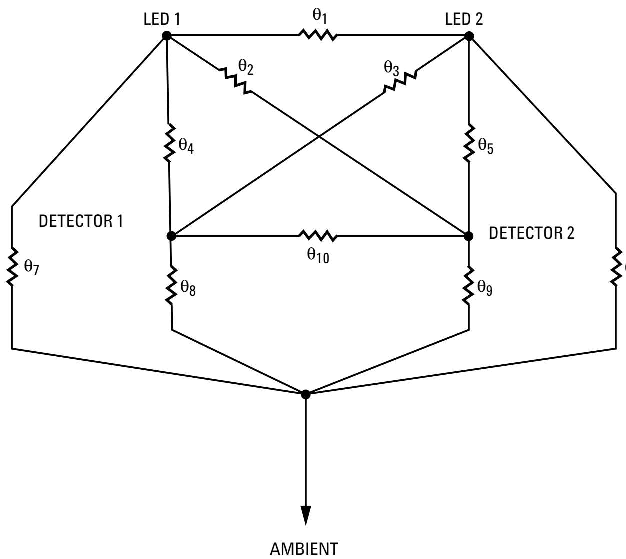


Figure 4. Thermal Model-D Diagram

Table 3. Thermal Model-D Coefficient Data (units in °C/W).

Part Number	A_{11}, A_{22}	A_{12}, A_{21}	A_{13}, A_{31}	A_{14}, A_{41}	A_{23}, A_{32}	A_{24}, A_{42}	A_{33}, A_{44}	A_{34}, A_{43}
HCPL-2430	308	92	101	91	91	101	162	112
HCPL-0738	383	188	179	196	193	178	249	200

Note: Maximum junction temperature for above part: 125 °C.

Thermal Model-E for a Single-Channel Optocoupler with Input Buffer Circuit

Definitions

θ_1, θ_2, θ_3, θ_4, θ_5, θ_6: Thermal resistances between nodes as shown in Figure 5.

Ambient Temperature: Measured approximately 1.25 cm above the optocoupler HCPL-7100/01 with no forced air and 2.54 cm around the optocoupler HCPL-0370 with no forced air.

Description

HCPL-7100/1 thermal model assumes that the optocoupler is soldered into an 8.5 cm x 8.1 cm printed circuit board (PCB). HCPL-0370 thermal model assumes that the optocoupler is soldered into a 7.62 cm x 7.62 cm low K board. These couplers are hybrid devices with three die: an input IC that drives the LED, an LED, and the detector IC. The temperature at the input IC, LED, and detector of this optocoupler can be calculated be using the equations below.

$\Delta T_{IA} = A_{11}P_I + A_{12}P_E + A_{13}P_D$

$\Delta T_{EA} = A_{21}P_I + A_{22}P_E + A_{23}P_D$

$\Delta T_{DA} = A_{31}P_I + A_{32}P_E + A_{33}P_D$

where:

ΔT_{IA} = Temperature difference between ambient and input IC

ΔT_{EA} = Temperature difference between ambient and LED

ΔT_{DA} =Temperature difference between ambient and detector

P_I = Power dissipation from input IC (Typical: 25 mW)

P_E = Power dissipation from LED (Typical: 10 mW when input Logic Low; less than 0.01 mW when input Logic High)

P_D = Power dissipation from detector (Typical 30 mW)

A_{11} through A_{33} thermal coefficients (units in °C/W) are functions of thermal resistances θ_1, θ_2, θ_3, θ_4, θ_5, θ_6.

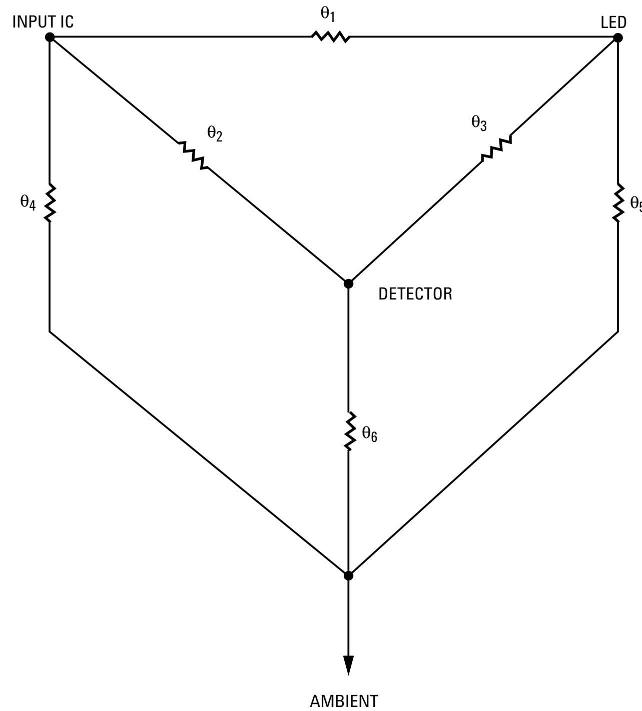


Figure 5. Thermal Model-E Diagram

Table 4. Thermal Model-E Coefficient Data (units in °C/W).

Part Number	A_{11}	A_{12}	A_{13}	A_{21}	A_{22}	A_{23}	A_{31}	A_{32}	A_{33}
HCPL-7100/1	206	133	103	133	299	115	103	115	193
HCPL-0370	240	191	141	205	328	167	165	173	255

Note: Maximum junction temperature for above part: 125 °C.

Thermal Model-F for a Single-Channel SO-5 Plastic-Package Optocoupler

Definitions

θ_1: Thermal resistance from LED junction to ambient

θ_2: Thermal resistance from LED to detector (output IC)

θ_3: Thermal resistance from detector (output IC) junction to ambient

Ambient Temperature: Measured approximately 2.54 cm around the optocoupler with no forced air.

Description

This thermal model assumes that a 5-pin single-channel plastic package optocoupler is soldered into a 7.62 cm x 7.62 cm low K printed circuit board (PCB). The temperature at the LED and Detector junctions of the optocoupler can be calculated using the equations below.

$\Delta T_{EA} = A_{11}P_E + A_{12}P_D$

$\Delta T_{DA} = A_{21}P_E + A_{22}P_D$

where:

ΔT_{EA} = Temperature difference between ambient and LED

ΔT_{DA} = Temperature difference between ambient and detector

P_E = Power dissipation from LED

P_D = Power dissipation from detector

A_{11}, A_{12}, A_{21}, A_{22} thermal coefficients (units in °C/W) are functions of the thermal resistances θ_1, θ_2, θ_3 (See Note 2).

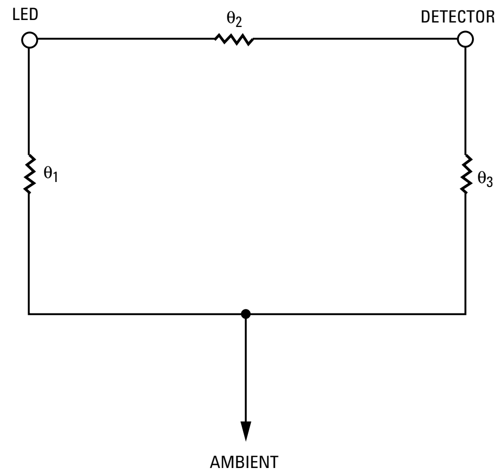


Figure 6. Thermal Model-F Diagram

Table 5. Thermal Model-F Coefficient Data (units in °C/W).

Part Number	A_{11}	A_{12}, A_{21}	A_{22}
HCPL-M601/M611	399	223	282

Notes:
1. Maximum junction temperature for above parts: 125 °C.
2. $A_{11} = \theta_1 \,||\, (\theta_2 + \theta_3)$; $A_{12} = A_{21} = (\theta_1\,\theta_3) / (\theta_1 + \theta_2 + \theta_3)$; $A_{22} = (\theta_1 + \theta_2) \,||\, \theta_3$.

Thermal Model-G for a Dual-Channel SO-16 Plastic-Package Optocoupler

Definitions

θ_1, θ_2, θ_3, θ_4, θ_5, θ_6, θ_7, θ_8, θ_9, θ_{10}: Thermal resistances between nodes as shown in Figure 7.

Ambient Temperature: Measured 1.25 cm above the optocoupler with no forced air.

Description

This thermal model assumes that a 16-pin dual-channel plastic package optocoupler is soldered into an 8.5 cm x 8.1 cm printed circuit board. These optocouplers are hybrid devices with four die: two LEDs and two detectors. The temperature at the LED and the detector of the optocoupler can be calculated by using the equations below.

$\Delta T_{E1A} = A_{11}P_{E1} + A_{12}P_{E2} + A_{13}P_{D1} + A_{14}P_{D2}$

$\Delta T_{E2A} = A_{21}P_{E1} + A_{22}P_{E2} + A_{23}P_{D1} + A_{24}P_{D2}$

$\Delta T_{D1A} = A_{31}P_{E1} + A_{32}P_{E2} + A_{33}P_{D1} + A_{34}P_{D2}$

$\Delta T_{D2A} = A_{41}P_{E1} + A_{42}P_{E2} + A_{43}P_{D1} + A_{44}P_{D2}$

Where:

ΔT_{E1A} = Temperature difference between ambient and LED 1

ΔT_{E2A} = Temperature difference between ambient and LED 2

ΔT_{D1A} = Temperature difference between ambient and detector 1

ΔT_{D2A} = Temperature difference between ambient and detector 2

P_{E1} = Power dissipation from LED 1;

P_{E2} = Power dissipation from LED 2;

P_{D1} = Power dissipation from detector 1;

P_{D2} = Power dissipation from detector 2

A_{XY} thermal coefficient (units in °C/W) is a function of thermal resistances θ_1 through θ_{10}.

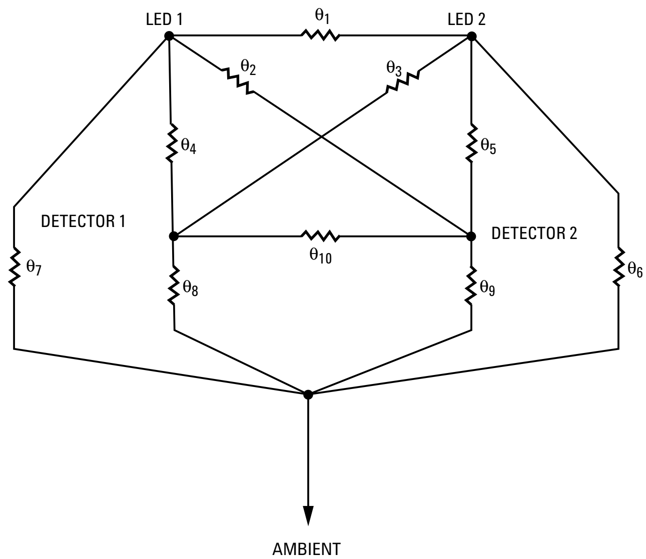


Figure 7. Thermal Model-G Diagram

Table 6. Thermal Model-D Coefficient Data (units in °C/W).

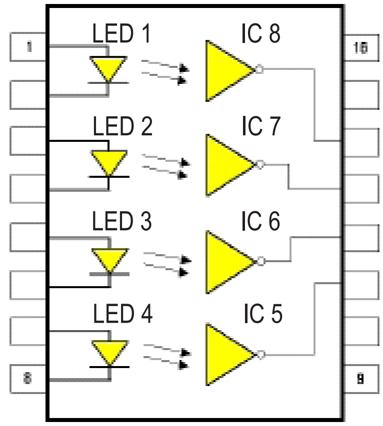
Part Number	A_{11}, A_{22}	A_{12}, A_{21}	A_{13}, A_{31}	A_{14}, A_{41}	A_{23}, A_{32}	A_{24}, A_{42}	A_{33}, A_{44}	A_{34}, A_{43}
HCPL-315J	198	64	62	83	90	64	137	69

Note: Maximum junction temperature for above part: 125 °C.

Thermal Model-H for a Quad Channel SOIC-16 Plastic-Package Optocoupler

Definitions

A_{11}, A_{12}, A_{13}, A_{14}, A_{15}, A_{16}, A_{17}, A_{18}, A_{21}, A_{22}, A_{23}, A_{24}, A_{25}, A_{26}, A_{27}, A_{28}, A_{31}, A_{32}, A_{33}, A_{34}, A_{35}, A_{36}, A_{37}, A_{38}, A_{41}, A_{42}, A_{43}, A_{44}, A_{45}, A_{46}, A_{47}, A_{48}, A_{51}, A_{52}, A_{53}, A_{54}, A_{55}, A_{56}, A_{57}, A_{58}, A_{61}, A_{62}, A_{63}, A_{64}, A_{65}, A_{66}, A_{67}, A_{68}, A_{71}, A_{72}, A_{73}, A_{74}, A_{75}, A_{76}, A_{77}, A_{78}, A_{81}, A_{82}, A_{83}, A_{84}, A_{85}, A_{86}, A_{87}, A_{88} :Thermal Coefficients (in °C/W) as a function of Thermal Resistances between nodes.



A_{11}: Thermal Coefficient as a function of Thermal Resistance of LED 1 due to heating of LED 1

A_{12}: Thermal Coefficient as a function of Thermal Resistance of LED 1 due to heating of LED 2

A_{13}: Thermal Coefficient as a function of Thermal Resistance of LED 1 due to heating of LED 3

A_{14}: Thermal Coefficient as a function of Thermal Resistance of LED 1 due to heating of LED 4

A_{15}: Thermal Coefficient as a function of Thermal Resistance of LED 1 due to heating of IC 5

A_{16}: Thermal Coefficient as a function of Thermal Resistance of LED 1 due to heating of IC 6

A_{17}: Thermal Coefficient as a function of Thermal Resistance of LED 1 due to heating of IC 7

A_{18}: Thermal Coefficient as a function of Thermal Resistance of LED 1 due to heating of IC 8

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A_{81}: Thermal Coefficient as a function of Thermal Resistance of IC 8 due to heating of LED 1

A_{82}: Thermal Coefficient as a function of Thermal Resistance of IC 8 due to heating of LED 2

A_{83}: Thermal Coefficient as a function of Thermal Resistance of IC 8 due to heating of LED 3

A_{84}: Thermal Coefficient as a function of Thermal Resistance of IC 8 due to heating of LED 4

A_{85}: Thermal Coefficient as a function of Thermal Resistance of IC 8 due to heating of IC 5

A_{86}: Thermal Coefficient as a function of Thermal Resistance of IC 8 due to heating of IC 6

A_{87}: Thermal Coefficient as a function of Thermal Resistance of IC 8 due to heating of IC 7

A_{88}: Thermal Coefficient as a function of Thermal Resistance of IC 8 due to heating of IC 8

Ambient Temperature: Measured approximately 8.89 cm horizontally and 2.54 cm vertically below from the edge of the test board.

Description

ACSL-6400 thermal model assumes that a 16-pin narrow body SOIC plastic package optocoupler ACSL-6400 is soldered onto a low conductivity 7.62 cm x 7.62 cm board per JESD 51-3. The quad channel optocouplers are hybrid devices with eight die: four LEDs and four ICs. The temperature at the LED and the IC of the optocoupler can be calculated by using the equations below:

$\Delta T_{E1A} = A_{11}P_{E1} + A_{12}P_{E2} + A_{13}P_{E3} + A_{14}P_{E4} + A_{15}P_{D5} + A_{16}P_{D6} + A_{17}P_{D7} + A_{18}P_{D8}$

$\Delta T_{E2A} = A_{21}P_{E1} + A_{22}P_{E2} + A_{23}P_{E3} + A_{24}P_{E4} + A_{25}P_{D5} + A_{26}P_{D6} + A_{27}P_{D7} + A_{28}P_{D8}$

$\Delta T_{E3A} = A_{31}P_{E1} + A_{32}P_{E2} + A_{33}P_{E3} + A_{34}P_{E4} + A_{35}P_{D5} + A_{36}P_{D6} + A_{37}P_{D7} + A_{38}P_{D8}$

$\Delta T_{E4A} = A_{41}P_{E1} + A_{42}P_{E2} + A_{43}P_{E3} + A_{44}P_{E4} + A_{45}P_{D5} + A_{46}P_{D6} + A_{47}P_{D7} + A_{48}P_{D8}$

$\Delta T_{D5A} = A_{51}P_{E1} + A_{52}P_{E2} + A_{53}P_{E3} + A_{54}P_{E4} + A_{55}P_{D5} + A_{56}P_{D6} + A_{57}P_{D7} + A_{58}P_{D8}$

$\Delta T_{D6A} = A_{61}P_{E1} + A_{62}P_{E2} + A_{63}P_{E3} + A_{64}P_{E4} + A_{65}P_{D5} + A_{66}P_{D6} + A_{67}P_{D7} + A_{68}P_{D8}$

$\Delta T_{D7A} = A_{71}P_{E1} + A_{72}P_{E2} + A_{73}P_{E3} + A_{74}P_{E4} + A_{75}P_{D5} + A_{76}P_{D6} + A_{77}P_{D7} + A_{78}P_{D8}$

$\Delta T_{D8A} = A_{81}P_{E1} + A_{82}P_{E2} + A_{83}P_{E3} + A_{84}P_{E4} + A_{85}P_{D5} + A_{86}P_{D6} + A_{87}P_{D7} + A_{88}P_{D8}$

where:

ΔT_{E1A} : Temperature difference between ambient and LED 1

ΔT_{E2A} : Temperature difference between ambient and LED 2

ΔT_{E3A} : Temperature difference between ambient and LED 3

ΔT_{E4A} : Temperature difference between ambient and LED 4

ΔT_{D5A} : Temperature difference between ambient and IC 5

ΔT_{D6A} : Temperature difference between ambient and IC 6

ΔT_{D7A} : Temperature difference between ambient and IC 7

ΔT_{D8A} : Temperature difference between ambient and IC 8

P_{E1} = Power dissipation from LED 1

P_{E2} = Power dissipation from LED 2

P_{E3} = Power dissipation from LED 3

P_{E4} = Power dissipation from LED 4

P_{D5} = Power dissipation from IC 5

P_{D6} = Power dissipation from IC 6

P_{D7} = Power dissipation from IC 7

P_{D8} = Power dissipation from IC 8

Table 7. Thermal Model-H Coefficient Data (units in °C/W)
Part Number: ACSL-6400

A11	A12	A13	A14	A15	A16	A17	A18	A21	A22	A23	A24	A25	A26	A27	A28
496	136	115	113	107	112	116	121	137	516	131	119	113	116	122	118
A31	**A32**	**A33**	**A34**	**A35**	**A36**	**A37**	**A38**	**A41**	**A42**	**A43**	**A44**	**A45**	**A46**	**A47**	**A48**
121	138	486	141	121	125	118	117	124	134	148	509	132	130	125	120
A51	**A52**	**A53**	**A54**	**A55**	**A56**	**A57**	**A58**	**A61**	**A62**	**A63**	**A64**	**A65**	**A66**	**A67**	**A68**
96	102	111	114	117	114	101	105	102	110	108	107	115	114	116	112
A71	**A72**	**A73**	**A74**	**A75**	**A76**	**A77**	**A78**	**A81**	**A82**	**A83**	**A84**	**A85**	**A86**	**A87**	**A88**
106	117	106	102	106	111	114	113	108	110	104	97	101	114	115	117

Note: Maximum junction temperature for above part: 125 °C.

Thermal Model-I for a Dual-Channel Bi-Directional SOIC-8 Plastic-Package Optocoupler

Definitions

A_{11}, A_{12}, A_{13}, A_{14}, A_{21}, A_{22}, A_{23}, A_{24}, A_{31}, A_{32}, A_{33}, A_{34}, A_{41}, A_{42}, A_{43}, A_{44}: Thermal Coefficients (in °C/W) as a function of Thermal Resistances between nodes.

A_{11}: Thermal Coefficient as a function of Thermal Resistance of LED 2 due to heating of LED 2

A_{12}: Thermal Coefficient as a function of Thermal Resistance of LED 2 due to heating of IC 1

A_{13}: Thermal Coefficient as a function of Thermal Resistance of LED 2 due to heating of LED 1

A_{14}: Thermal Coefficient as a function of Thermal Resistance of LED 2 due to heating of IC 2

A_{21}: Thermal Coefficient as a function of Thermal Resistance of IC 1 due to heating of LED 2

A_{22}: Thermal Coefficient as a function of Thermal Resistance of IC 1 due to heating of IC 1

A_{23}: Thermal Coefficient as a function of Thermal Resistance of IC 1 due to heating of LED 1

A_{24}: Thermal Coefficient as a function of Thermal Resistance of IC 1 due to heating of IC 2

A_{31}: Thermal Coefficient as a function of Thermal Resistance of LED 1 due to heating of LED 2

A_{32}: Thermal Coefficient as a function of Thermal Resistance of LED 1 due to heating of IC 1

A_{33}: Thermal Coefficient as a function of Thermal Resistance of LED 1 due to heating of LED 1

A_{34}: Thermal Coefficient as a function of Thermal Resistance of LED 1 due to heating of IC 2

A_{41}: Thermal Coefficient as a function of Thermal Resistance of IC 2 due to heating of LED 2

A_{42}: Thermal Coefficient as a function of Thermal Resistance of IC 2 due to heating of IC 1

A_{43}: Thermal Coefficient as a function of Thermal Resistance of IC 2 due to heating of LED 1

A_{44}: Thermal Coefficient as a function of Thermal Resistance of IC 2 due to heating of IC 2

Ambient Temperature: approximately 8.89 cm horizontally and 2.54 cm vertically below from the edge of the test board.

Description

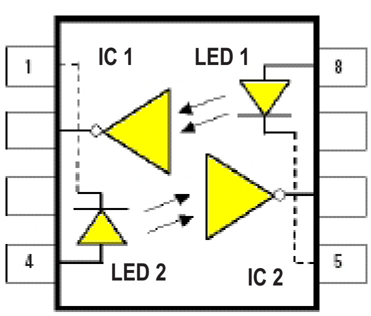
ACSL-6210 thermal model assumes that an 8-pin narrow body dual-channel bi-directional plastic package optocoupler is soldered onto a low conductivity 7.62 cm x 7.62 cm board per JESD 51-3. These optocouplers are hybrid devices with four die: two LEDs and two ICs. The temperature at the LED and the IC of the optocoupler can be calculated by using the equations below:

$$\Delta T_{E2A} = A_{11}P_{E2} + A_{12}P_{D1} + A_{13}P_{E1} + A_{14}P_{D2}$$

$$\Delta T_{D1A} = A_{21}P_{E1} + A_{22}P_{D2} + A_{23}P_{E2} + A_{24}P_{D1}$$

$$\Delta T_{E1A} = A_{31}P_{E1} + A_{32}P_{D2} + A_{33}P_{E2} + A_{34}P_{D1}$$

$$\Delta T_{D2A} = A_{41}P_{E1} + A_{42}P_{D2} + A_{43}P_{E2} + A_{44}P_{D1}$$



where:

ΔT_{E2A} : Temperature difference between ambient and LED 2

ΔT_{D1A} : Temperature difference between ambient and IC 1

ΔT_{E1A} : Temperature difference between ambient and LED 1

ΔT_{D2A} : Temperature difference between ambient and IC 2

P_{E2} = Power dissipation from LED 2

P_{D1} = Power dissipation from IC 1

P_{E1} = Power dissipation from LED 1

P_{D2} = Power dissipation from IC 2

Table 8. Thermal Model-I Coefficient Data (units in °C/W)
Part Number: ACSL-6210

A11	A12	A13	A14	A21	A22	A23	A24	A31	A32	A33	A34	A41	A42	A43	A44
560	120	121	184	117	209	179	109	117	186	526	116	166	100	106	203

Note: Maximum junction temperature for above part: 125 °C.

Thermal Model-J for a S04 Plastic Package Solid State Relay

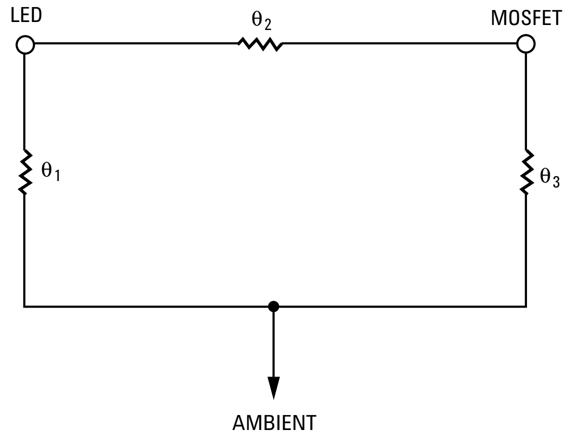


Figure 1. Thermal Model Diagram

	θ_1 (°C/W)	θ_2 (°C/W)	θ_3 (°C/W)
2 layer JEDEC board	272	114	461

Details:

Definitions

θ_1: Thermal resistance from LED junction to ambient

θ_2: Thermal resistance from MOSFET (output IC) junction to ambient

θ_3: Thermal resistance from LED to MOSFET

Ambient Temperature: Measured approximately 1.25 cm above the SSR, without forced air flow.

Description

This thermal model assumes that a 4-pin single-channel plastic package SSR is soldered into an 8.5 cm x 8.1 cm printed circuit board (PCB). The temperature at the LED and MOSFET junctions of the SSR can be calculated using the equations below.

$$\Delta T_{EA} = A_{11}P_E + A_{12}P_M \quad (1)$$

$$\Delta T_{MA} = A_{21}P_E + A_{22}P_M \quad (2)$$

where:

ΔT_{EA} = Temperature difference between ambient and LED

ΔT_{MA} = Temperature difference between ambient and MOSFET

P_E = Power dissipation from LED

P_M = Power dissipation from MOSFET

A_{11}, A_{12}, A_{21}, A_{22} thermal coefficients (units in °C/W) are functions of the thermal resistance θ_1, θ_2, θ_3

Note:

1. Maximum junction temperature for above parts: 125°C.
2. $A_{11} = \theta_1 \,||\, (\theta_2 + \theta_3)$ (3)
   $A_{12} = A_{21} = (\theta_1\ \theta_3) / (\theta_1 + \theta_2 + \theta_3)$ (4)
   $A_{22} = (\theta_1 + \theta_2) \,||\, \theta_3$ (5)

We do not provide the θ_{JC} data here. The reason is that θ_{JC} is used for the situation where a heat-sink is mounted on the device. In most of the applications, heat-sink is not used for a SSR. θ_{JC} is measured in a setup to make sure all the heat is dissipated through the heat-sink. Hence, the following relationship is met:

$$\theta_{JA} = \theta_{JC} + \theta_{CS} + \theta_{SA} \quad (6)$$

θ_{JA}: Thermal resistance of junction to ambient

θ_{JC}: Thermal resistance of junction to case

θ_{CS}: Thermal resistance of case to heat-sink

θ_{SA}: Thermal resistance of heat-sink to ambient

Sometimes, engineers want to estimate the junction temperature (T_j) at a device according to the top surface temperature (Ttop) of the device. A relationship between the T_{top}, power P and T_j can be set up, by

$$R_{jt} = (T_j - T_{top}) / P \quad (7)$$

But this Rjt is not the thermal resistance of junction to case. It will not follow equation (6).

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