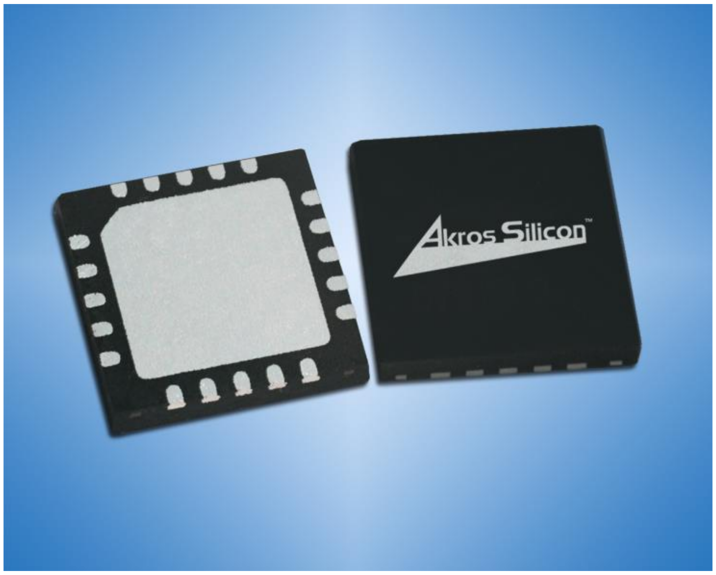
Application Note AN022

# AS1138 Thermal Characterization Report

Revision 1.0, March 2017



The AS1138 chip has been characterized in the Kinetic Engineering Lab for thermal performance. Not only has there been an estimation of the IC junction temperature, but a temperature profile for the entire system has also been compiled over a range of power dissipation levels.

## AS1138 Design Targets and Constants:

Package thermal constants are:

$\Theta_{ja}$ (Junction to Ambient) = 31ºC/W

$\Theta_{jc}$ (Junction to Case) = 3.4ºC/W

AS1138 Max power consumption = 1.2W

AS1138 measured nominal power consumption = 0.9W

The following equations can be used to estimate the die-temperature based on these thermal constants:

$$T_{junction} = T_{ambient} + \Theta_{ja} * P_{diss}$$

or

$$T_{junction} = T_{case} + \Theta_{jc} * P_{diss}$$

Based on the above max power consumption, the following **WORST-case temperatures** can be derived:

| $T_{ambient}$ (ºC) | $T_{case}$ (ºC) | $T_{Junction}$ (ºC) |
|---|---|---|
| 25 | 58.1 | 62.2 |
| 40 | 73.1 | 77.2 |
| 70 | 103.1 | 107.2 |
| 85 | 118.1 | 122.2 |

These calculations show that the junction temperature of the device is just about 4ºC above the case temperature as measured at the copper paddle of the device.

## Customer X Board Characterization:

Customer X board is a 4-layer

**Configuration:**

- DUT: Customer X PoE Board #5
- Part: AS1138A2 part # 3

**Setup:**

- Lab Bench: 03
- DUT Power: DC Power Supply (Agilent 6634B) connected to DUT RJ45 power input
- DUT Load: Eload (HP 6063B) connected to DUT output header – J1, pins 49/50-1/2 (12V DC-DC output)
- Thermal Probes: Type K thermocouple attached to AS1138 case, Type K thermocouple placed near DUT to monitor air temperature
- Thermometer: Fluke 52 II
- Oven: Despatch LBB1-23A-1
- Thermal Environment: DUT placed in oven

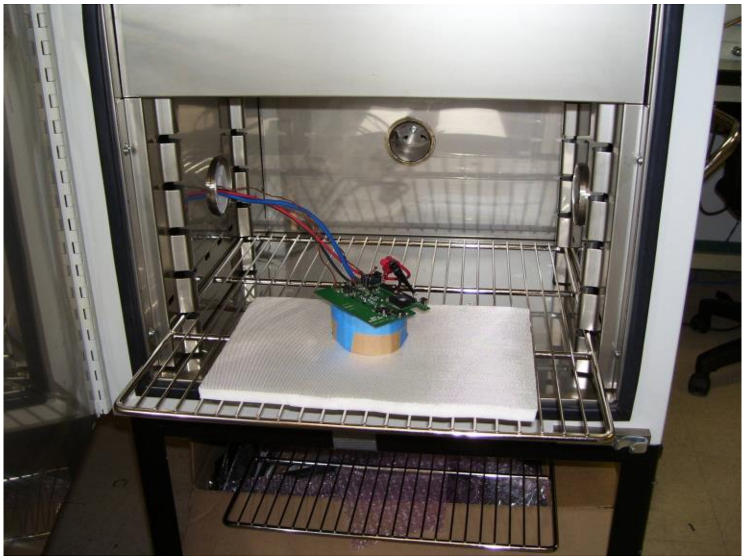


**Figure 1: Thermal Characterization Test Setup**

**Procedure:**

1. Power up DUT (48V nom.) and adjust Eload for 30W nom. input to RJ45.
2. Ramp air temperature to 40 degC nom. and monitor AS1138 case temperature.
   - Stable measurement condition: < 1degC temperature excursion over 15 minute observation period

**Results:**

- Input: 48.01V, 0.6217A (29.85W)
- Output: 12.0V, 2.0A
- Ambient Temp.: 44.8 degC
- Case Temp.: 72.8 degC
- Soak Time: 1 hr.
- AS1138 Power dissipation: 0.9W

Based on above measurements, we can back calculate thermal constants.

$\Theta_{ja}$ = (72.8 – 44.8)/0.9W = 31.1ºC/W
Using $\Theta_{jc}$ of 3.4ºC/W => Operation $T_{junction}$ = 72.8 + 0.9W*3.4 = 75.8 ºC

## Correlation:

Above measurement correlates well with the package design targets.

The AS1138 is designed in an automotive silicon process that is qualified at 160ºC. Reliability data for the silicon process indicates that operation under 145ºC limit will result in an overall failure rate of less than 21 FIT (1 failure / billion devices).

## Thermal Considerations at the System Level:

Although the package-level analysis of the AS1138 indicates that the IC temperature is well within the limits for a typical application, the AS1138 component temperature should be considered only as part of the overall system temperature profile, including temperatures of other potentially hot components such as FETs, diodes, etc. These other components may, in fact, be more of a limiting factor. Figure 2 shows the device temperatures for the key components within an AS1138 regulator. Case temperatures have been measured at an ambient temperature, $T_A$ = 25°C. Not surprisingly, the AS1138 IC temperature is noticeably lower than the temperatures associated with power components such as FETs and diodes, especially as the power level is raised. For power regulators in general, it is expected that the main power components such as FETs and diodes would be the hottest devices operating in the system regardless of the PD/PWM IC controller used. Specifically, in Kinetic' testing, the primary PWM FET (outside of the AS1138) tends to be the hottest component in the system. Thus, no matter which PD/PWM IC controller is used, the highest temperature in the system is mostly a function of the FETs Rds-on and primary current.

Below testing is done on the AS1138 Synchronous Flyback 5V/30W design. Component description is as follows: U4=AS1138, T1=Power Transformer, Q3=Primary FET, Q4=Sync FET, D10 & D11 are the diode bridges.

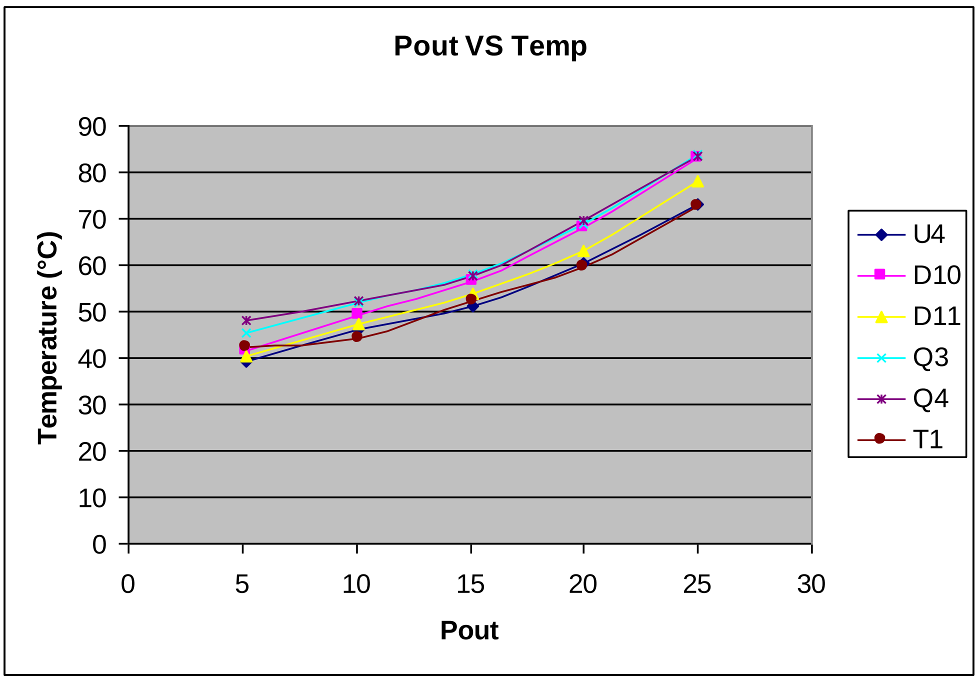



**Figure 2: Component Temperatures within the AS1138 System**

For designs having similar power efficiency, the power loss on the board should be the same. Furthermore, for a given board size and equivalent copper content, the resulting average board temperatures should be similar across those designs. Because the component temperatures are impacted by the size and copper plating weight of the PCB, the customer should take care when evaluating and comparing thermal performance across different hardware platforms. In particular, when making estimates from an evaluation board, it is important to understand whether that board design accurately reflects the actual PCB stack-up, size, and plating weight of the final application.

Good thermal performance does require adherence to appropriate board layout guidelines so that the PCB can act as a good heat sink. Please refer to Kinetic Technologies Application Note AN018 for QFN Layout Guidelines.

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