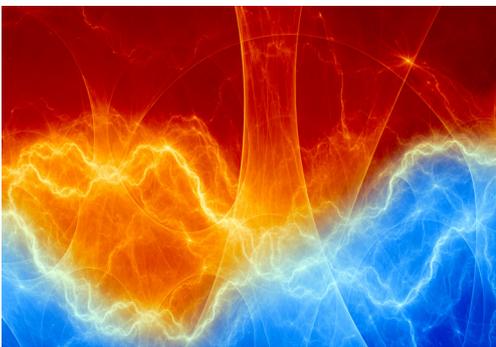


**White Paper**

# Defining Wide Temperature for Industrial Memory Applications

## Executive Summary



Wide temperature DRAM modules operate within the range of  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ . These modules are designed to tackle harsh environmental conditions seen by applications such as in-vehicle, factories, networking, and outdoor kiosks as well as the surveillance and defense markets.

The wide temperature specifications are based on the JEDEC standards for DRAM integrated circuits (IC), with the JEDEC Standard 21C outlining the specifications for standard DRAM modules. These outline the basic specifications of wide temperature DRAM and together with testing procedures and quality control it lays the groundwork for how to design industrial-grade, wide temperature memory.

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## Introduction

Memory is an essential component in every computer, no matter the size and application. All edge devices must, therefore, be ready to tackle any thermal and physical hardship posed by the environment.

This is ever more crucial as we keep moving and more computing power to the edge to decrease latency and create more efficient systems.

What this means is that devices previously located in a centralized and stable location are now placed where the actual data is gathered. These locations can be anything from a factory floor, a busy road intersection or onboard a ship or an airplane. One of the main challenges that tie these applications together is wide temperature variations.

While temperature variations can be part of natural cycles, climate change is another factor that can affect future and already existing systems, as it in many places can lead to more unstable weather and unforeseeable changes.

This paper will explain the background of DRAM wide temperature specifications, as well as its application and testing procedures.

## Background

The specification 'industrial-grade wide temperature' is usually defined by the temperature range  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ . For Innodisk, these numbers are based on JEDEC specifications that are further expanded on to suit industry requirements.

### JEDEC

JEDEC is an organization that develops open standards for the microelectronics industries. The standards are created through tight-knit cooperation between manufacturers and suppliers and are employed on a worldwide basis. For standard temperature DRAM, the applicable standard is 21C. For wide temperature, there are separate standards that outline specifications for different DRAM types. The standards describe in detail both manufacturing requirements and testing of wide temperature DRAM modules.

## Challenges

The trends of IoT and edge computing both contribute to more devices and computational power being placed in harsher environments. These include both places with extreme heat and cold, as well as areas susceptible to the adverse consequences of climate change.

For example, a device placed outside will run through a continuous cycle of heating and cooling with the change from day to night, and on a longer cycle with seasonal changes. These locations can also be hard to access which increases the time and cost of maintenance.

It is imperative that devices that run in these areas utilize memory modules that can handle these circumstances over long periods with minimal attendance.



Outdoor Applications



Aircraft



Transportation

## Solutions

### JEDEC Standards

The JEDEC Standard specifies the temperature range for the whole DRAM module and DRAM integrated circuits (IC) respectively. Innodisk follows this guideline which also states that maximum  $T_C$  shall not exceed the value specified for the DRAM component.

The temperature range for DRAM modules is designated as  $T_A$ , which refers to the ambient temperature. JEDEC puts this range at:

$$0^{\circ}\text{C} \leq T_A \leq 55^{\circ}\text{C}$$

The case temperature ( $T_C$ ), which refers to the temperature of the IC during operations, will naturally be higher as it is at least the same as the ambient temperature with heat produced during operations added on top. I.e.,  $T_C$  is equal to  $T_A$  plus heat produced. JEDEC sets this range to:

$$0^{\circ}\text{C} \leq T_C \leq 85^{\circ}\text{C}$$

The Innodisk standard for wide temperature modules is built on the JEDEC standard and is further extended into the negative range:

$$-40^{\circ}\text{C} \leq T_A \leq 85^{\circ}\text{C}$$

This range allows modules to operate in environments that significantly surpass the JEDEC standard, both for ambient and IC temperature (as  $T_C$  is always the same or higher than  $T_A$ ).

### Testing and Quality Control

To verify wide temperature capability, as well as robustness and product quality, the modules will run through a standardized testing process as seen below.

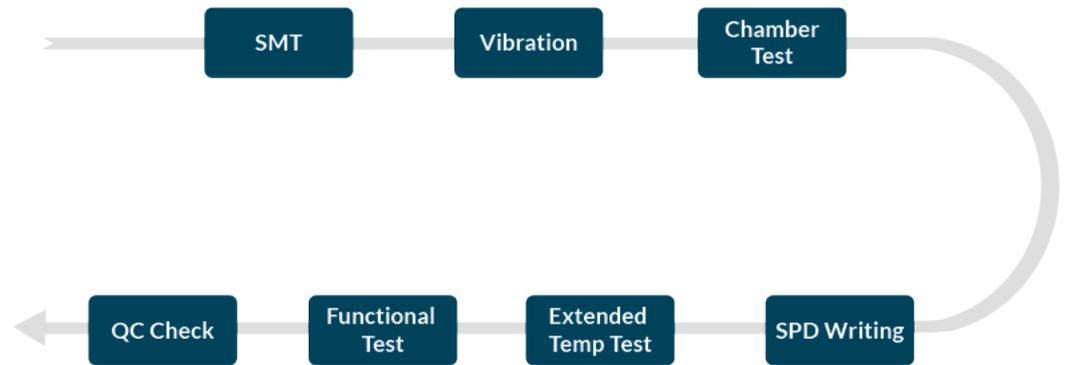


Figure 1: Wide temperature testing process

Once having cleared this process, the modules are verified for use in wide temperature environments.

## Conclusion

Wide temperature specifications are crucial in ensuring that your device survives the extreme conditions seen in the surveillance, in-vehicle, factory, networking, and mission-critical markets. The need for wide temperature memory is set to increase as computational power moves out into the field where robust IoT devices are essential for longevity and efficient maintenance.

Wide temperature plays a part in the wider set of tools that ready memory for harsh environments. Combining it with anti-sulfuration, coating, side fill, and heat spreader allows the operator to tailor a solution specific to their application.

## The Innodisk Wide Temp DDR4, DDR3, and DDR2 DRAM Family

Module		DDR4		DDR3		DDR2	
Form factor	Spec	Capacity	Data Rate	Capacity	Data Rate	Capacity	Data Rate
	WT UDIMM	Standard	4/8/16	2133/2400 /2666	2/4/8	1066/1333/ 1600/1866	
ECC		4/8/16	2133/2400 /2666	2/4/8	1066/1333/ 1600/1866		
VLP		8/16	2400				
WT SODIMM	Standard	4/8/16/32*	2133/2400 /2666	2/4/8/16	1066/1333/ 1600/1866	1/2	533/667 /800
	ECC	4/8/16/32*	2133/2400 /2666	2/4/8/16	1066/1333/ 1600/1866		
WT RDIMM	ECC	4/8/16/32	2133/2400 /2666				
	VLP	4**/8/16	2133/2400 /2666				

\* 32GB : Will launch in 2019 2H

\*\* DDR4 WT RDIMM VLP : 4GB is only for 2133MT/s and 2400MT/s

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