EM759X Finite Element Thermal Model
2174326-Rev 3

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Content Level	BASIC		INTERMEDIATE		ADVANCED	✓	Confidentiality	Public	✓	Private	

Hardware Compatibility	Product Line	IoT Modules	Series	EM7590	
				EM7595	

Software Compatibility	ALL	Document Type	App Note	✓	Tech Note	

1 Version

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2 Introduction

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Note: In this document:

- *EM759X refers to EM7590 and EM7595.*

3 Glossary

Term	Definition
CA	Carrier Aggregation (For details, see https://www.3gpp.org/technologies/keywords-acronyms/101-carrier-aggregation-explained.)
FEM	Finite Element Model
system box	A simulation construct that models a real-world test setup

4 Overview

To use an AirPrime EM759X module in LTE bands at full transmit power over long periods, thermal energy must be dissipated to keep the module within its operating temperature specifications.

This document provides an overview of the Finite Element Model (FEM) setup used for thermal simulation of an EM759X module. This thermal model can be used to conduct the customer's product thermal simulation.

5 Test Unit Details

The EM759X module is a key-B 30x42 mm M.2 device. All components are located on the top side. The bottom side of the unit is a gold-plated flat surface that can be used to place a heatsink to dissipate the heat.

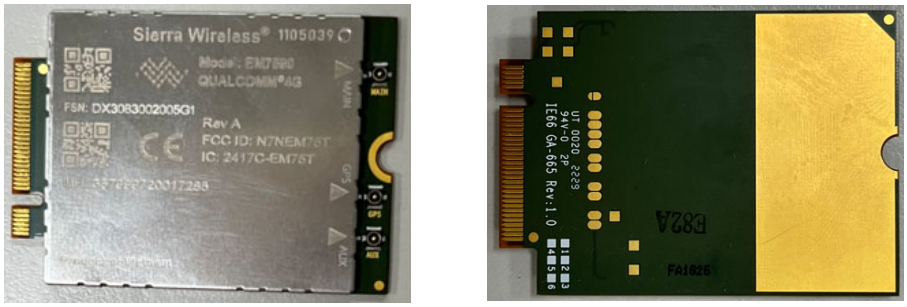

Figure 1: EM759X Module—Top and Bottom Surfaces

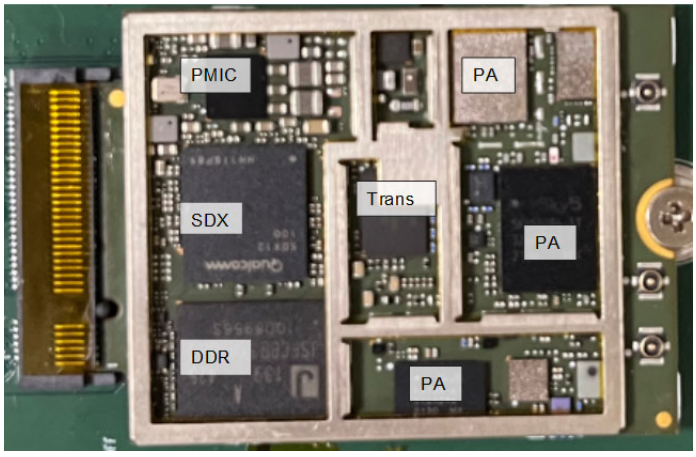

Figure 2: EM759X Module—Critical Internal Components

Figure 2 shows the critical components inside an EM759X test unit. All the named components generate heat.

6 FEM Simulation Setup

The EM759X test unit FEM was set up using the FloTHERM CFD simulation tool and *[1] EM759X Thermal Model Design File*, which can be directly imported to FloTHERM.

The simulations were conducted with an assembled unit. The assembled unit is a system box (Figure 3) that represents the environment in which the physical experiments were conducted. The system box contains the EM759X test unit connected to a host board via the M.2 connector (Figure 4). This model does not use a heatsink. For reference, Figure 5 shows the actual EM759X on a host board.

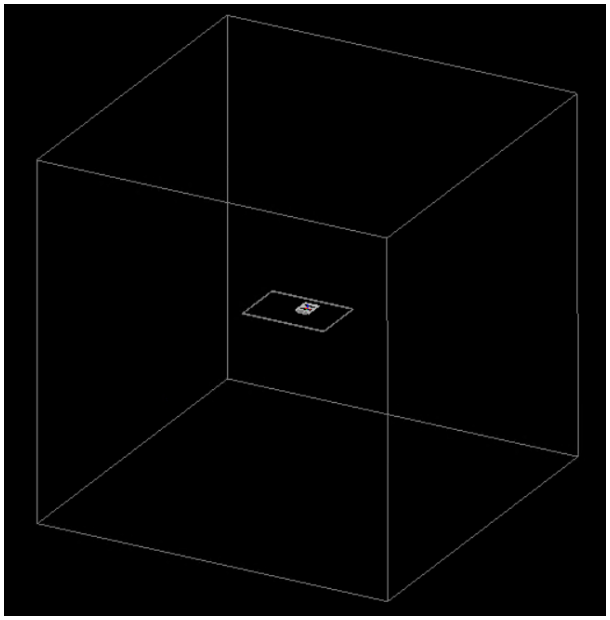

Figure 3: Thermal model full setup in system box

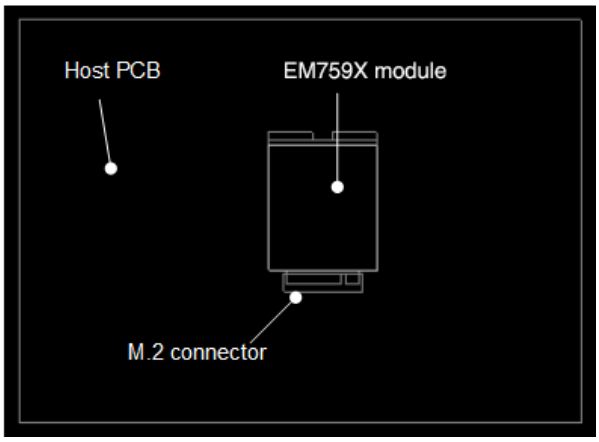

Figure 4: Thermal model full setup with EM759X on host board

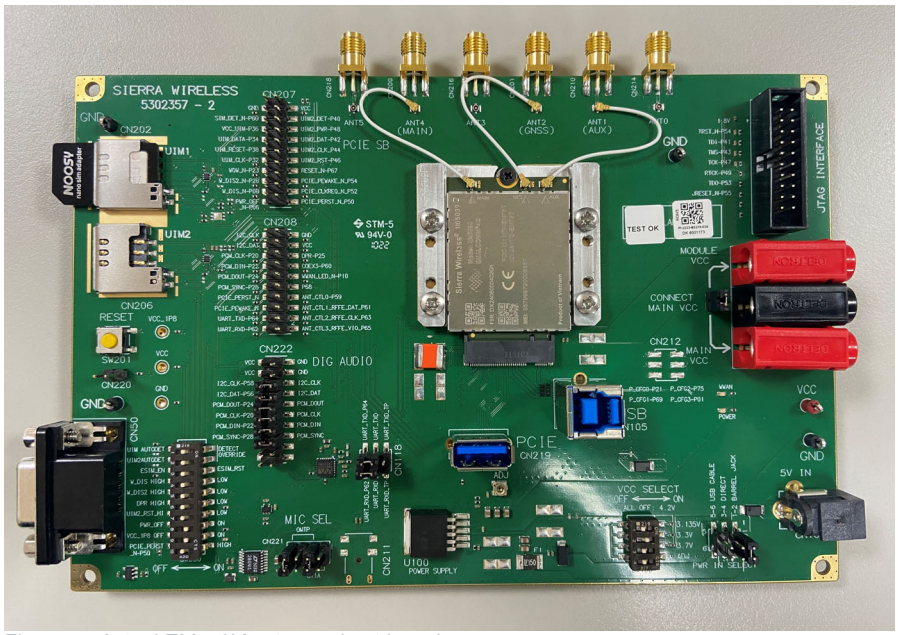

Figure 5: Actual EM759X setup on host board

7 Material Properties

Table 1 summarizes the material properties entered in the simulation to represent the materials from the actual physical test setup. These material properties control the thermal conduction in the system.

Table 1: Simulation Model—Material Properties

Material	Conductivity k (W/(mK))	Resistivity (Ω·m)	Density (kg/m^3)	Specific Heat Cp ($\frac{J}{kg \cdot K}$)
Copper (pure)	401	1.7e-8	8960	386
FR4	0.58	>1.0e14	1300~1500	900~1100
Dielectric	0.58	>1.0e14	1300~1500	900~1100
Shielding cover	16.3	0.73e-6	7930	500
Shielding frame	25.2	2.6e-6	8700	399

8 Geometries

Geometry is a block of material in the simulation environment that represents an actual component. Figure 6 illustrates how the EM759X module geometries are positioned in the simulation, and Table 2 provides the actual geometry sizes.

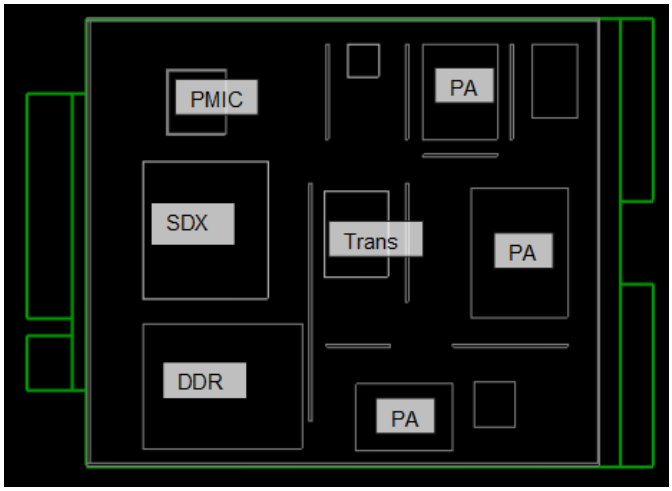

Figure 6: Simulation—Geometry Positioning

Table 2: Simulation—Geometry Dimensions

Component	Dimensions (mm)		
	X	Y	Z
System box	800	800	800
Host PCB	185.0	124.0	1.75
M.2 connector	22.0	5.0	3.0
EM759X PCB	30.0	41.99	0.82
SDX12	9.20	8.40	0.757
JSFCBB3YH3FBG-425A	8.3	10.7	0.8
PMD9655	4.44	3.94	0.497
SDR660	5.8	4.3	0.492
QET6150	2.2	2.12	0.51
SKY58096	8.6	6.5	0.65
SKY53735	4.5	6.51	0.7
SKY58260	6.4	5.0	0.85
SKY58258	5.0	3.0	0.7
SKY53728	3.1	2.8	0.7
EM759X shielding	30.0	34.4	1.5

9 Boundary Conditions & Assumptions

Boundary settings define the environment around the EM759X unit and influence thermal properties inside the whole system.

9.1 System Box Boundary Parameters

The system box represents the environment in which the physical experiments were conducted.

Table 3 describes the boundary conditions used for the system setup.

Table 3: System Box Boundary Parameters

Attribute	Project Definition	Description
Solution type	Flow & Heat transfer	Attributes that define air and module heat exchange properties.
Dimensionality	3D	Attributes that define coordinate system dimensions.
Ambient	40°C	Attributes that define conditions outside the module.
Fluid	40°C @ 1 atm pressure	Attributes that define surrounding cooling or heating fluid.
Gravity	Normal, -Z	Attributes that define gravitational force direction and angle to the module. The Z-axis is the direction facing the top side of the module.
Grid constraint	Medium with component localization	Attributes that define minimum grid requirements over and near to objects.

9.2 Test Unit Parameters

The EM759X test unit is connected to a host board inside the system box.

Table 4 describes the boundary conditions used in the EM759X thermal model.

Table 4: Test Parameters

Attribute	Project Definition	Description
Thermal model	SDX12, JSFCBB3YH3FBG-425A, PMD9655, SDR660, QET6105, SKY58096, SKY58258, SKY58260, SKY53735, SKY53728	Attributes that define heat sources. The set values are in terms of power.
Source	SDX12, JSFCBB3YH3FBG-425A, PMD9655, SDR660, SKY58096	
2-Resistor model	SKY58096, SKY58258, SKY58260	Attributes that define simplified models.

10 Power Distributions

There are several heat sources in the EM759X module. To get proper heat distribution, a good measurement or assumption of power consumption must be set for each heat source.

For example, the power distribution for LTE full TX configuration (EM7595—3CA, EM7590—2CA) with the module connected to a host board without using a heatsink is shown in Table 5.

Table 5: EM759X Components—Power Distribution (Full Performance)

Component	SDX12	JSFCBB3YH3FBGH425A	PMD9655	SDR660	SKY58096
Power (W)	1.14	0.14	0.27	0.25	2.9

11 Temperature Contour Plots

The following figures illustrate heat propagation across the EM759X module and into its environment.

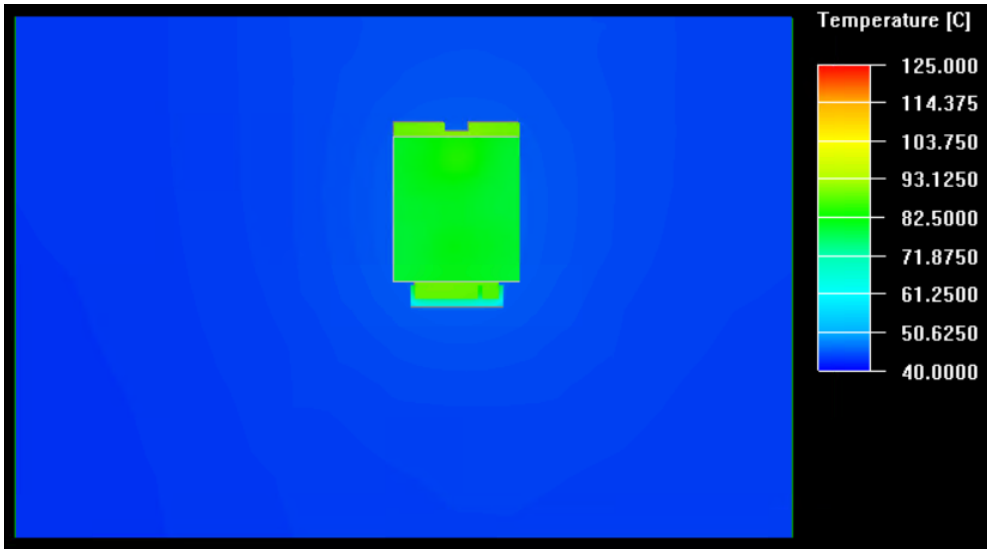

Figure 7: Temperature Contour—Entire models

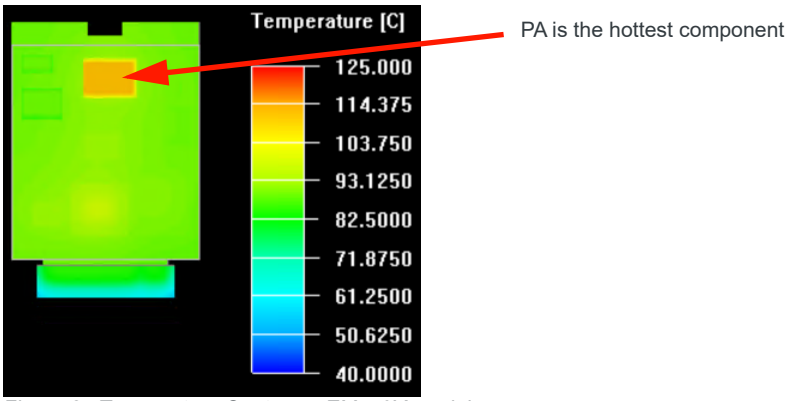

Figure 8: Temperature Contour—EM759X module

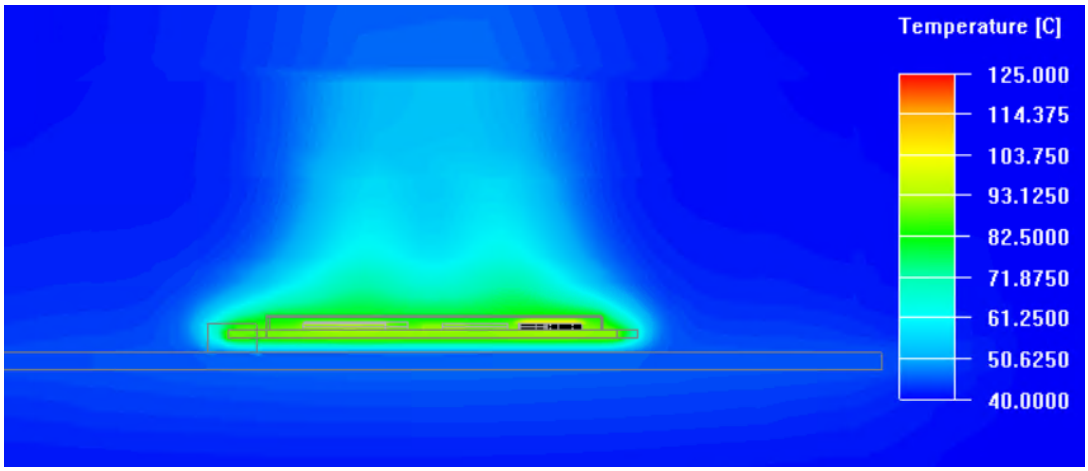

Figure 9: Entire System—Heat radiation Cross-Section View

12 Velocity Vectors

Velocity vectors characterize the movement of air. These diagrams show the properties of the air at a given point in the model, including speed, temperature, pressure, etc.

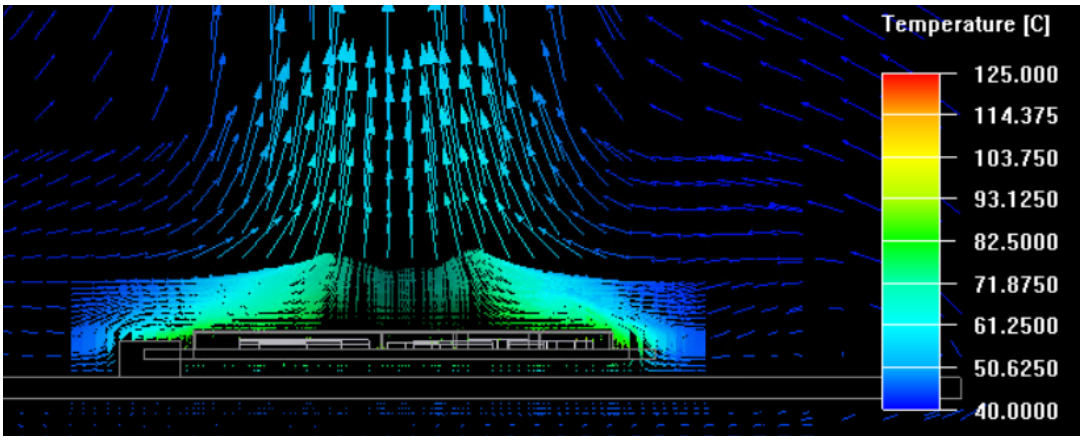

Figure 10: Temperature Velocity Vectors—Angled View

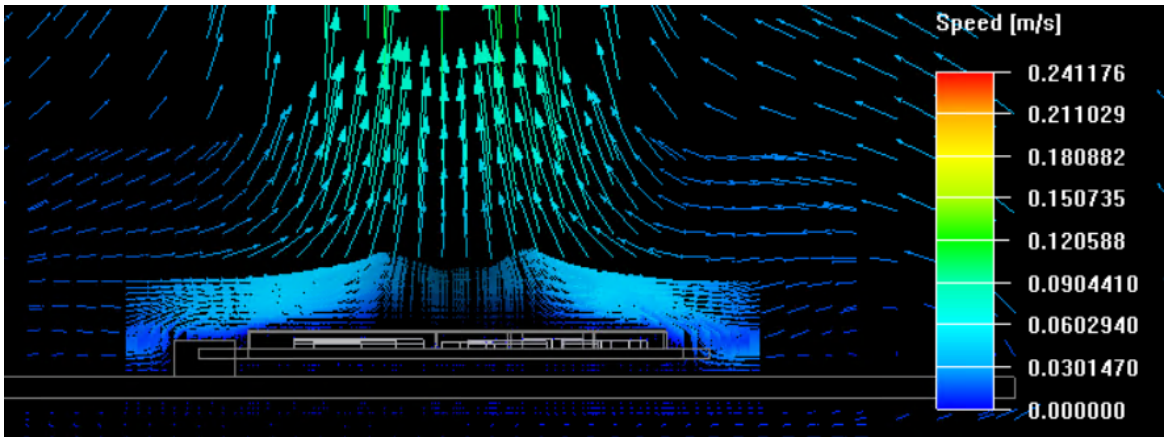

Figure 11: Air Velocity Vectors—Angled View

13 Interpretation of Simulation Results

- Material properties used in these simulations are based on values found in the literature and from vendor data sheets.
- This methodology has correlated well with existing temperature measurements and is deemed to be adequate for predicting thermal performance of EM759X modules.
- The thermal model design file Sierra Wireless provided is the EM759X module itself. Actual temperature response will be dependent on host configuration, type of printed circuit board and ambient conditions.

14 Resources

The following resources are available from Sierra Wireless under NDA.

Document	Document #	Description
[1] EM759X Thermal Model Design File	41114452	Thermal model file for import to FloTHERM

15 Support

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For distributors: contact your Sierra Wireless FAE

16 Document History

Revision	Release Date	Changes
1	April 08, 2022	Creation
2	June 2023	Replaced Ansys Icepak references with FloTHERM or general references Updated Test Unit Details (Figure 1) Updated FEM Simulation (Figure 3, Figure 4, Figure 5) Updated Table 2, Simulation—Geometry Dimensions (Host PCB dimensions, renamed component DDR to JSFCBB3YH3FBG-425A) Updated Table 4, Test Parameters (Thermal model and Source Project Defnition values) Updated Power Distributions (Added example text and Table 5, EM7590 Components—Power Distribution (Full Performance) Updated Temperature Contour Plots (Figure 7, Figure 8, Figure 9) Updated Velocity Vectors (Figure 10, Figure 11)
3	August 2023	Added EM7595, replaced EM7590 references with EM759X

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