OEM TD-CDMA PCI Express Mini Module Integration Guide

V01.01

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1 General

1.1 Approvals and Dates

	Approval Date
W. J. Jones	

1.2 Change Record

Date	Version	Author	Reason For Change Issue
30/08/2013	01.00	PFW	New Document.
30/09/2013	01.01	PFW	Updated RF Exposure information

1.3 Acronyms

Term	Definition
TD-CDMA	Time Division – Code Division Multiple Access
MPE	Maximum Permissible Exposure
OEM	Original Equipment Manufacturer
PCIe	PCI Express
PCI SIG	PCI Special Interest Group
PEM	PCI Express Mini
SIM	Subscriber Identity Module
USB	Universal Serial Bus

1.4 External References

Ref ()	Number	Title
1	FCC Part 15	Radio Frequency Devices
2	FCC Part 22	Public Mobile Services
3	FCC Part 24	Personal Communication Services
4	FCC Part 27	Miscellaneous Wireless Communications Services
5	FCC Part 90	Private Land Mobile Radio Services
6	PCI SIG	PCI Express Base Specification Revision 2.0
7	PCI SIG	Card Electromechanical Specification Revision 2.0
8	IPWireless	PEM + Adapter Thermal Specification Revision 1.0

Note: Where a reference is undated, the latest version applies unless a specific revision is defined.

2 Introduction

This document describes the method of integrating the General Dynamics Broadband TD-CDMA PCI Express Mini module into an OEM product.

2.1 Scope of Document

This document applies to the following General Dynamics Broadband TD-CDMA PCI Express Mini modules.

- Model: AAU.

2.2 Overview of Module

The General Dynamics Broadband TD-CDMA PCI Express Mini module provides a complete TD-CDMA wireless modem solution and only requires the module to be inserted in a PCI Express Mini compliant interface and connection of external antennas. The module is designed to minimise the time and resource required to integrate TD-CDMA into an end-user product.

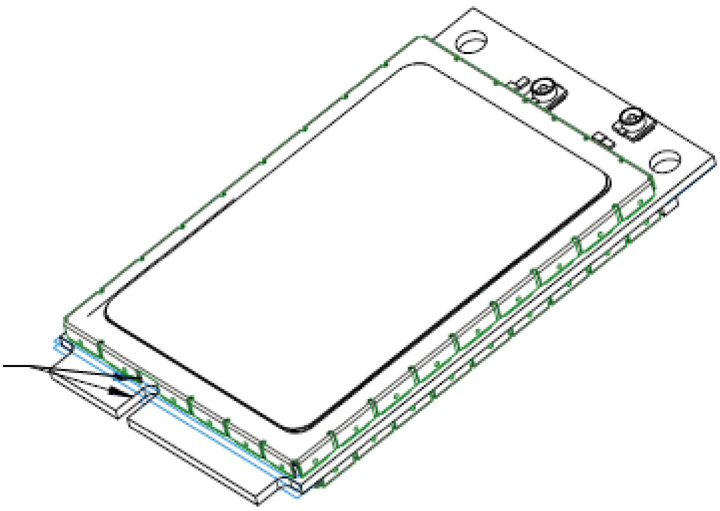

Figure 1: TD-CDMA PEM

3 Module Connections

3.1 PCI Express Mini Interface (J1)

The General Dynamics Broadband TD-CDMA PCI Express Mini module is provided with a 52 pin edge connector for connection to the external application. This connection supports the following interface types and these are described below. The pinout is shown in Annex 1.

3.1.1 Universal Serial Bus

The PCI Express edge connector provides a USB 2.0 interface, this interface supports low speed (1.5Mbps), full speed (12Mbps) and High speed (480Mbps) operation.

3.1.2 SIM Interface

The PCI Express edge connector provides a 4 line SIM interface to allow use with Subscriber Identity Modules if required, this interface supports both 1.8V and 3.0V SIM's. The SIM interface does not provide ESD protection and this should be provided by the host device.

3.1.3 Co-existence Pins

The co-existence pins COEX1,2 are currently not supported by the TD-CDMA PEM.

3.2 RF Connections

The General Dynamics Broadband TD-CDMA PCI Express Mini module provides two RF connections for external antennas. The main port must be connected, the diversity port may or may not be connected depending upon application. The connector type is the Hirose U.FL series.

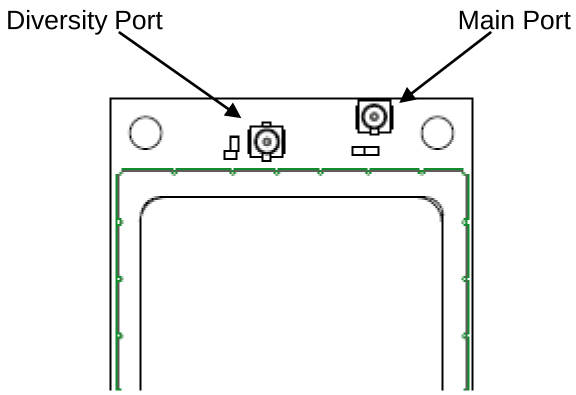

Figure 2: TD-CDMA PEM RF Connections

3.3 DC Power

The module requires a DC supply of between 3.0V to 3.6VDC with the nominal voltage being 3.3VDC, maximum input current is 950mA at 3.3VDC (3.1Watts). DC power is applied to the module via the PCI Express Mini edge connector.

3.4 Management of Radio Receiver Self-Interference

The General Dynamics Broadband TD-CDMA PEM is supplied as a stand-alone PCI Express Card, or can be mounted on an General Dynamics Broadband TD-CDMA Adaptor card. It is the customer who then has to integrate the PEM - either on a Host Circuit Board, or mounted within their own Host Equipment, at which point, the location of the antennas which connect to the PEM are outside of General Dynamics Broadband control.

Any radio receiver is susceptible to in-band RF interference in its receive band and it is of paramount importance that the PEM Host Equipment Integration Design team are aware of and take countermeasures to prevent ***all*** Host Equipment, in-band RF interference from reaching the PEM's Antennas.

The PEM as a unit is fully shielded by design, external RF Interference from the Host Equipment is extremely unlikely to get into the TD-CDMA Radio receiver on the PCB and will be coupled to the receiver by other means. Any Interference from the Host Equipment in the TD-CDMA receive band(s) will degrade the TD-CDMA receiver performance if present at the antennas. Any such receiver interference is a called an RF "Blocking signal". The closer the TD-CDMA PEM's antenna system is relative to the source of any blocking signals, the worse will be the degradation in Rx Sensitivity suffered by the TD-CDMA PEM and subsequent customer-perceived Host Equipment performance.

Due to the extremely high performance of the TD-CDMA PEM RF Receivers, tiny levels of in-band interference may cause major loss of performance. To put this in perspective, the Class B EMC limit is approximately 70dB **higher** than the smallest signal that the TD-CDMA Receiver can receive (receiver sensitivity is approximately -123dBm (-16dBµV).

Therefore host equipment which is compliant with relevant EMC emission regulations is likely to cause interference and performance degradation to the TD-CDMA PEM receivers.

However, all of the EMC design countermeasures must be applied when designing the Host Equipment, to prevent RF Blocking signals – they are the first line of suppression and are good design practice. Each engineering discipline: Digital, Power, RF, Mechanical and Thermal must be involved from the outset, to provide the suppression performance required.

3.4.1 PCB Level

Any PCB with high-clock rate digital signals, imperfect supply rails and any signals with fast edges must be carefully designed during layout to produce a low emission profile PCB.

By listing the speeds of all clocks, processors and busses, then computing their harmonics up to 2690MHz, it is simple to see which parts of the circuitry are most likely to generate RF Blocking signals. Believing that any of those harmonics will destroy RF Receiver performance if they are not suppressed by design and then being meticulous attention during layout are the key to suppressing them at source.

a. Top and bottom surfaces should be flood-filled with a copper ground plane and tracking on the outer layers should be avoided.

b. The perimeter of the PCB should have ground copper on each layer and all layers should be stitched with ground vias.

c. There must be no slots in the surface ground planes or apertures above fast-moving signals on inner layers – particularly digital buses.

d. Care should be taken to provide ground current return paths for all power circuitry, for the digital ICs and particularly the clock ICs.

e. Provision should be made for shielding all components on the PCB.

f. Designers must be aware that PCB connectors contain exposed metal which will radiate and design and shield accordingly. Provision should be provided for options to link connector shields to PCB ground if the best way is not clear, or is not known.

3.4.2 Unit Level

The ideal way to suppress RF interferers is to enclose all of the active circuitry in a metal can without holes or joins. Unit level shielding, either SMT or PTH aims go get as close to an ideally shielded metal box as possible within the constraints of reality – i.e. functionality and cost.

a. SMT shielding should be used to cover all components on each side of any PCB that might radiate into the Antenna System.

b. The shielding system should be fully integrated with the PCB surface flood fill ground planes with small distances between connection points.

c. The shielding system should be un-lidded or have many mechanical connection points around the perimeter of the lids used.

d. Special attention should be paid to signals that must travel outside of the metal shield to suppress/filter high speed edges – e.g. R/C filters on LED driving signals.

e. Shielded PCB sockets must be chosen for all interconnect signals and the shield metal must correctly routed and grounded, separate to any circuit ground or power signals carried within the connection bus.

f. Wherever possible, always, filter every interconnect signal, inside the metal shields, with the appropriate filtering components, including the power signals.

g. Whilst instances are much rarer, it should be noted that the UE Transmit signal is capable of inducing false edges onto unshielded digital signals when they are operating in close proximity to antennas carrying pulsed, maximum power Tx signals (notably GSM).

3.4.3 Connecting Cables

Choosing the unshielded version of an interconnect but connector system is a false economy if a high sensitivity RF receiver antenna is nearby. Always use the shielded system from the outset and design it in correctly as detailed above. The socket and connector shields are as much part of the shielding as the flood-fill PCB ground planes.

a. If a cable end-connector does not encompass all of the cable cores with a shield then it will radiate. Ensure the connector is fully shielded.

b. If the drain wire/foil/sheath of a shielded cable is not correctly connected to the metal shield within the cable-end connector then it will radiate.

c. If both ends of a shielded cable cannot be shielded (e.g. 100m Ethernet) then ensure that it is at the far end of the cable that the shield is not connected, not the TD-CDMA PEM Antenna end.

3.4.4 System Level

Some choices made at the system level can directly affect the Receive performance on the TD-CDMA PEM, as follows.

a. If possible, ensure that the main lobes of the PEM's antenna system (particularly if it is directional) are not pointing at either the Host Equipment electronics. Assume that all active electronics radiate RF Blockers until proven otherwise. E.g. If the User Equipment is placed in the trunk of a vehicle and the antennas are cabled onto the roof of a car, that's good.

b. If possible, specify a metal enclosure for the Host Equipment if the PEM's antennas have to be, or might be mounted in close proximity.

c. Provide an RF connection point on the Host Equipment to which the customer can connect an alternative remote antenna and make the remote antenna available as an approved accessory.

d. Provide an extension cable with the Host Equipment which will allow the customer to move it away from interfering equipment and make the extension cable available as an accessory E.g. a USB cable to allow the Host Equipment to be moved away from a PC.

e. Processor clocks often determine core clocking speeds and bus switching speeds, both of which use significant power. If possible, select a clock rate which has no in-band harmonics, ensure the clock rate can be varied or change to a processor that provides this flexibility.

3.4.5 Provision for "Production Modifications" of Host Equipment

Caution: This section only applies to the host equipment, changes to the TD-CDMA PEM are prohibited.

Sometimes it is not possible to guarantee that the PCB or Unit design will generate RF interference, or not. In these instances, it is preferable – at least on the initial spin of a PCB to provide features to allow correction of problems without delaying deliveries of 1st Pass or prototype Host Equipment.

1. Kapton tape covered by self-adhesive copper foil can effectively prevent unshielded PTH pins, SMT Test-points, Debug points or core vias from radiating. Design apertures into the solder resist to expose bare copper to allow insulative Kapton tape to be applied over the radiators, then conductive adhesive copper tape over the kapton, which can be stuck to the exposed copper, if required.

2. RF suppressor material can sometimes suppress RF blocking signals effectively enough to allow a sub-optimal card to perform adequately whilst a solution is engineered on a following revision of PCB. It is useful to have a sample stock of various materials, along with space in the design (in the likely places) to apply RF suppressor materials, if needed.

3. Conductive paint can be retrospectively applied to the inside of plastic enclosures to provide a level of shielding. The level achieved depends on the design of the enclosure, particularly it's split line design and the sizes of vents and holes within it. It is good practice to design to allow inner paint shielding at the outset, if required.

4. A simple and effective way to determine if a product is being desensitised by RF Blocking from the Host Electronics is to measure receiver performance, then wrap the entire unit up in an EMC bag (with just the antennas outside), then re-measure and compare the receiver performance.

5. Be aware that most consumer electronics (especially PCs) are designed to just pass EMC Class B limits and are huge sources of RF Blockers/interference for 3G and 4G wireless systems. When the Host Equipment performs as specified, placing it in close proximity to a PC, Tablet, TV or even a Phone may destroy TD-CDMA receive performance. The end-customer must be made tactically aware of this.

4 Mechanical

The General Dynamics Broadband TD-CDMA PCI Express Mini module is designed to be installed in a PCI Express compliant slot capable of holding an F1 full size mini card.

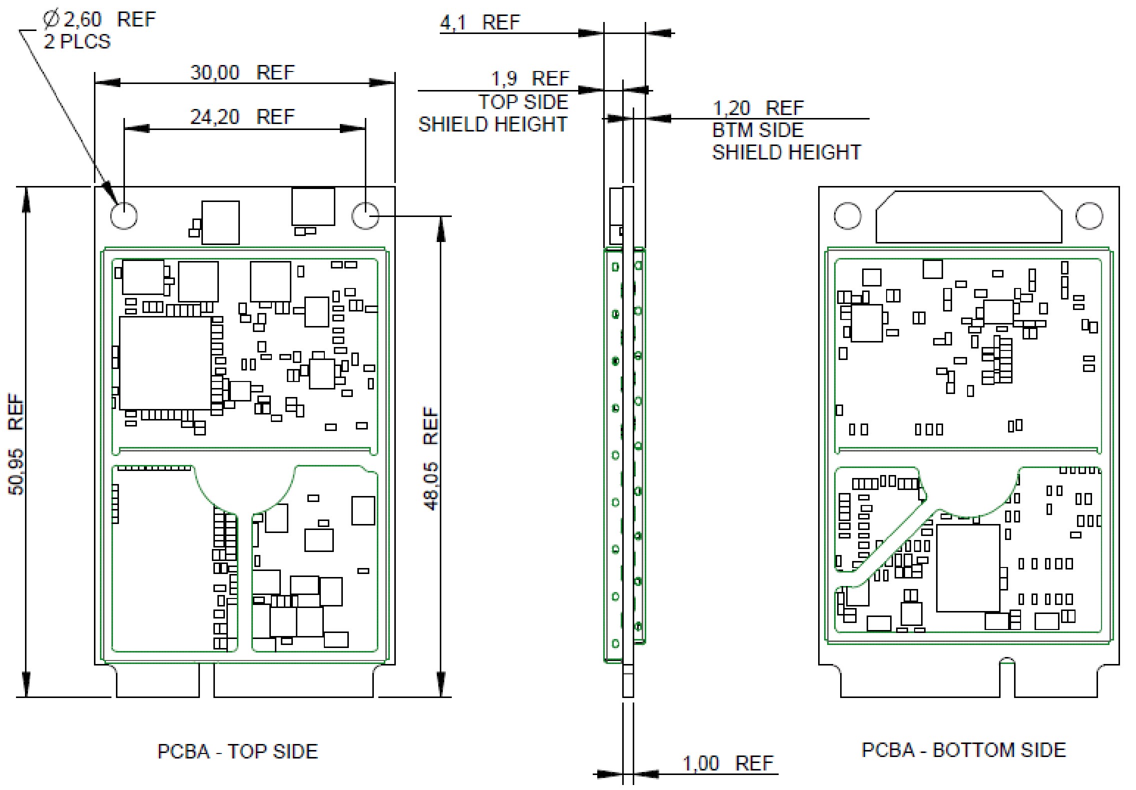

Figure 3: TD-CDMA PEM Module - detail

4.1 Thermal Management

The General Dynamics Broadband TD-CDMA PCI Express Mini module integration shall be in accordance with the PCISIG thermal requirements.

This section describes the thermal specifications for the General Dynamics Broadband TD-CDMA PCI Express Mini Card plus Adaptor and provides recommendations for thermal cooling schemes within the two configurations and covers the following:

4.1.1 PEM Thermal Specification

Parameter	Rating	Comments
Power Dissipation:	3.1 Watts	@ 3.3VDC
Ambient Air Specification:	-30°C to +70°C	PCI Standard 1.2 -30C to +65C
Maximum Temperature Rise	+25°C	
PEM PCB Construction	10 Layer ½ oz copper	

Table 1: PEM Thermal Specification

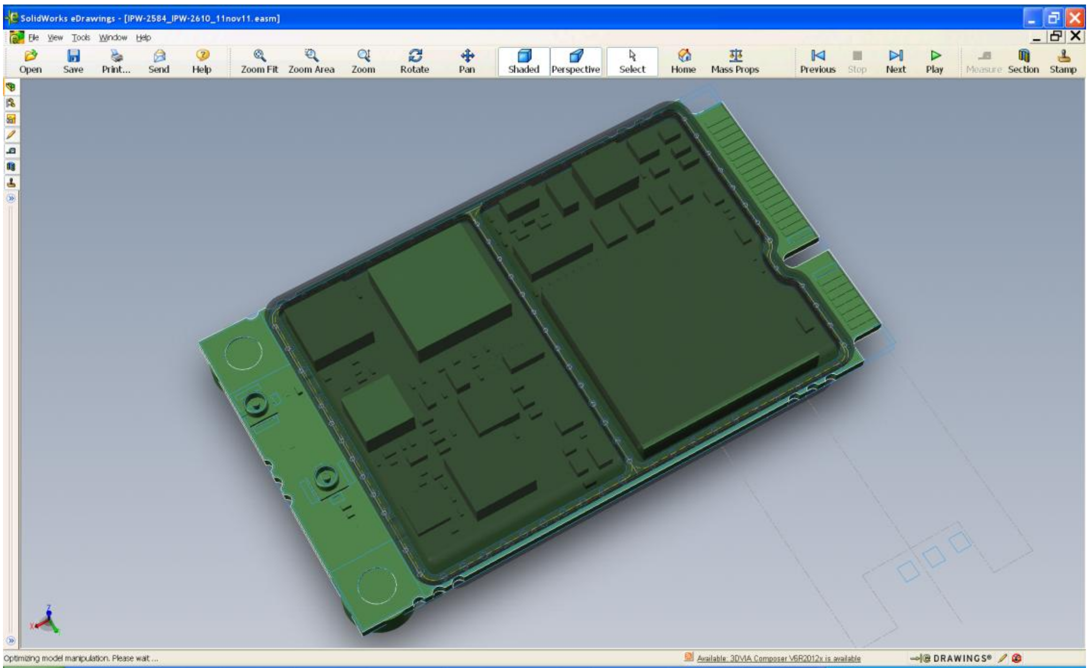

Figure 4: PEM Unit Assembly - Top

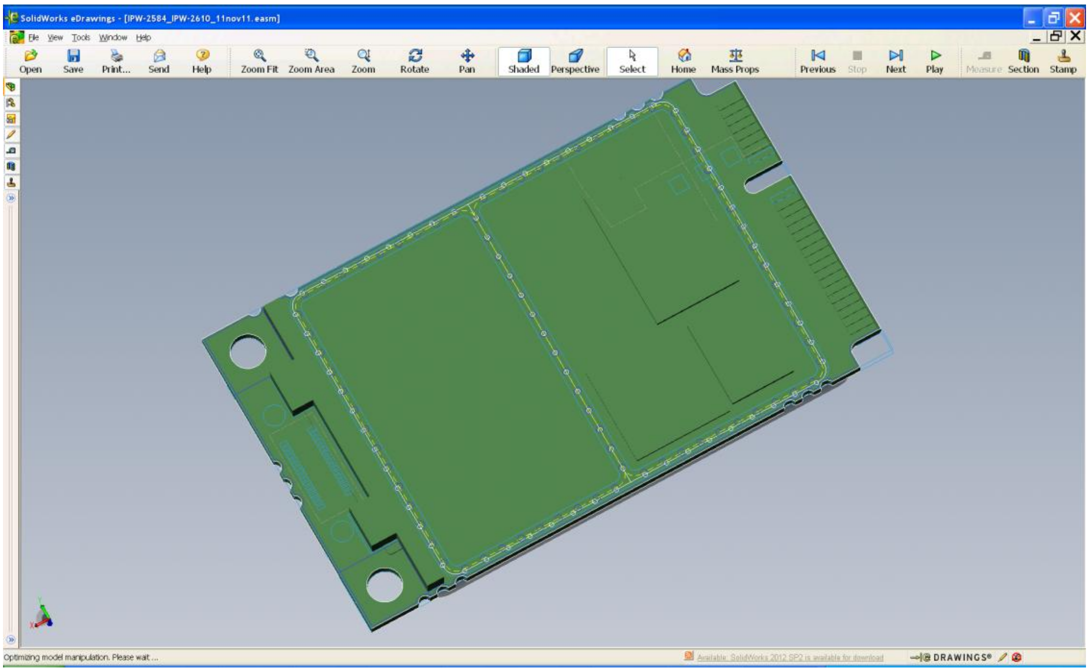

Figure 5: PEM Unit Assembly Bottom

4.1.2 PEM and TD-CDMA Adaptor Thermal Specification

Parameter	Rating	Comments
Power Dissipation:	8.0 Watts	@ 24.0VDC
Ambient Air Specification:	-30°C to +70°C	PCI Standard 1.2 -30C to +65C
Maximum Temperature Rise	+25°C	
PEM PCB Construction	10 Layer ½ oz copper	No components fitted to bottom.

Table 2: PEM and Adapter Thermal Specification

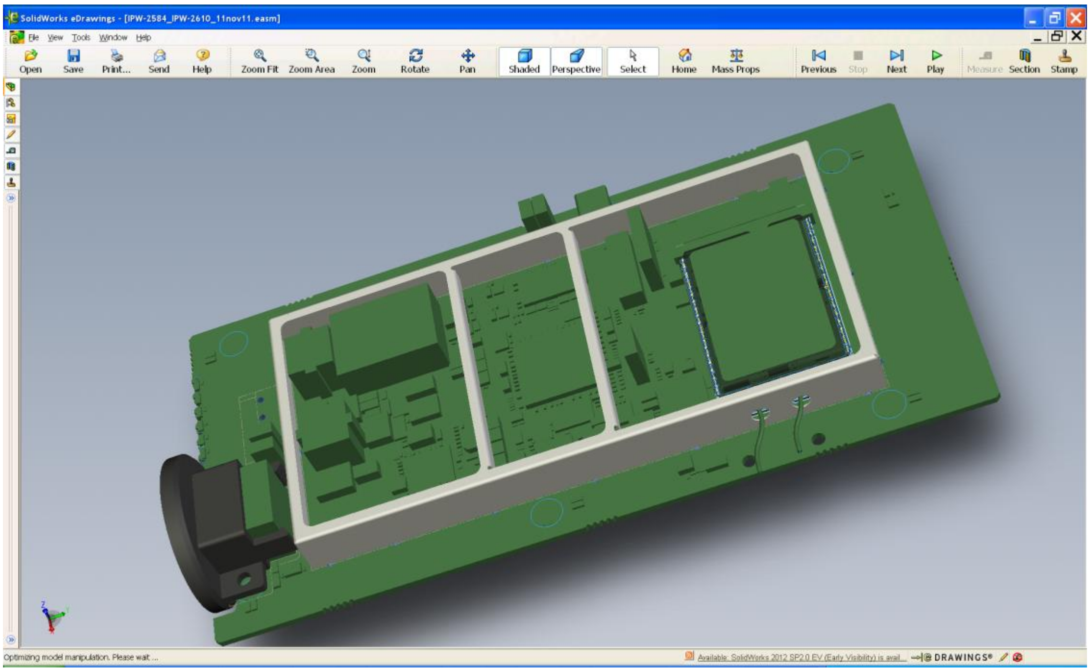

Figure 6: PEM and Adapter Assembly - Top

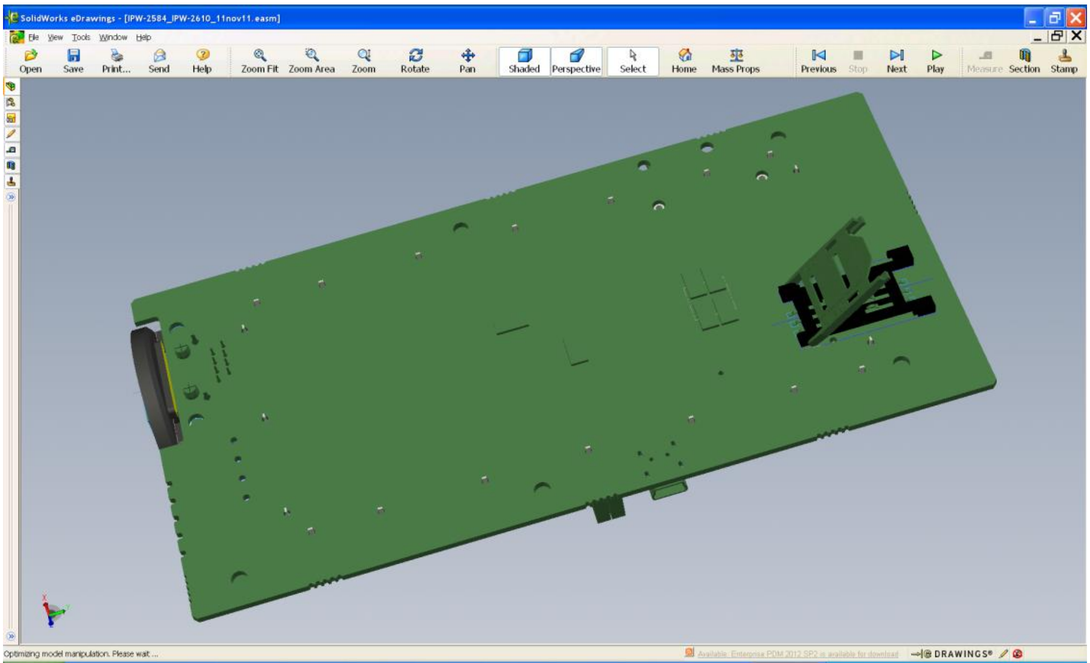

Figure 7: PEM and Adaptor Assembly - Bottom

4.1.3 Physical Thermal Arrangement – PEM and Adaptor

This section describes the thermal arrangement of the PEM and Adaptor assembly.

The arrangement is architected to maximize the heat transfer from the PEM to the Adaptor Card by creating a low thermal resistance between the PEM and the Adapter board. A similar scheme will be described for laptop installations.

a) The layer structure of PCB – PEM see section 3.1 above, to spread heat to use the full surface area of the PCB.

b) The layer structure of PCB – PEM Adaptor see section 3.2 above, to spread heat to use the full surface area of the PCB and to provide a thermal conduction path through the base of the enclosure.

c) Use of a graphite thermal spreader material on top of top shielding can.

d) Use of an aluminium foil unit label covers top of unit and facilitates conduction and spreader on the top surface of the PEM unit assembly.

e) graphite spreader/interface material on bottom of bottom snapshot shield to interface between bottom snapshot and adaptor board.

f) gaps between components and shielding cans are filled with thermal gasket in the short term, longer term the shielding can shall be contoured in contact with the components.

g) thermal conduction through the 52way connector has also provided significant thermal conduction path to the adaptor board.

h) thermal conduction through the SMT threaded mounting bosses on the TD-CDMA PEM Adaptor PCB.

4.1.4 PEM and Adaptor Simulated Environment within theoretical enclosure

The PEM and Adaptor has been thermally simulated with the following sectioned enclosure to maintain a maximum 20°C temperature rise above ambient, i.e. max 90°C ambient.

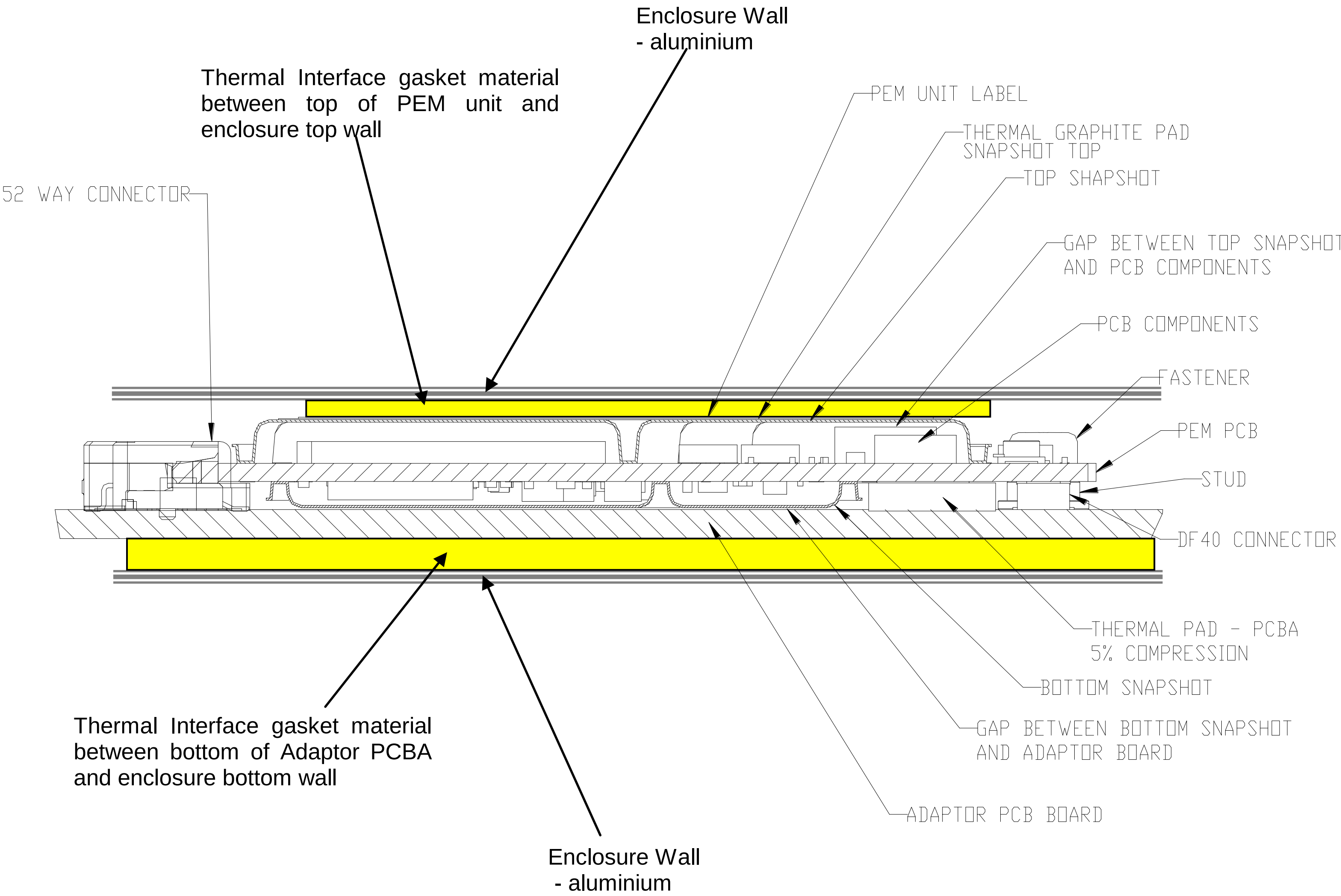

Figure 8: PEM and Adapter Thermal Assembly Structure Section

4.1.5 Recommendations for thermal cooling schemes

This section specifies the recommendations for the installations for the two configurations below.

- PEM and Adaptor Configurations.
- PEM in laptop Configurations.

4.1.6 PEM and Adaptor

This configuration is planned to be within a die-cast enclosure and the following features are recommended to add to the construction.

- bottom of TD-CDMA PEM Adaptor to casing small as possible gap filled with an thermal interface material typically 1mm thermal gasket. Examples of interface material.
  - T-Global L37-3 or L37-5, thermal conductivity gasket.
    - http://www.tglobal.com.tw/en/index.php
  - WL Gore CP6000 or CP8000, thermal conductivity gasket.
    - http://www.wlgore.com
- Top of PEM Assembly cover add thermal gasket to contact interface to enclosure top cover.
- Orientation of the enclosure vertical.
- Finned externals of the enclosure orientated vertically.
- Mounting of the enclosure in an orientation to encourage convective airflow over fins.
- Mounting to make use of mounting structure.
- Airflow to be encouraged over the surface of the fin as much as possible.

4.1.7 PEM in Laptop

The TD-CDMA PEM has been integrated into two laptops and this has shown that additional thermal pads are required to be placed between the TD-CDMA PEM and the laptop motherboard to assist the heat spreading in these host units.

5 Regulatory Information – Model AAU 2.5GHz Band.

NOTE: This module is not suitable for installation in products that are required to meet ATEX or other Hazardous Location requirements.

5.1 FCC Requirements for North America

5.1.1 Compliance with FCC Rules and Regulations

The General Dynamics Broadband PCI Express Mini module AAU, is certified as a module for mobile applications against FCC Parts 15 & 27 for operation in the EBS/BRS frequency allocation defined as 2496-2690MHz operating as a Time Division Duplex device.

Band	Uplink (Transmit)	Downlink (Receive)
2.5GHz EBS/BRS	2496 – 2690MHz	2496 – 2690MHz

IMPORTANT: Manufacturers of devices containing the General Dynamics Broadband TD-CDMA PCI Express Mini module Model AAU are advised to.

1. Clarify any regulatory questions, particularly if the host device contains other radio transceivers.
2. Have their final product tested and approved for compliance with FCC rules.
3. Include instructions with the final product regarding meeting the RF Exposure requirements of the FCC rules.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Caution: Changes or modifications not covered in this document must be approved in writing by the General Dynamics Broadband. Changes or modifications made without written approval may void the user's authority to operate this equipment.

5.1.2 FCC Labelling Requirements

This module is certified under FCC ID: PKTPEMAAU2, if the FCC ID on the module label is not visible from the outside of the host device then an additional label is required on the outside of the host device.

This label is required to state 'Contains FCC ID: *PKTPEMAAU2'.*

5.1.3 Exposure to Radio Frequency Signals

The RF exposure evaluation/compliance of the module is for use in mobile host equipment and the module should be installed and operated with a minimum separation distance of 20cm between the antenna and the user, otherwise the host product requires re-approval.

The host equipment manufacturer must supply a user RF exposure warning statement that states a minimum 20cm usage distance is required from the antenna in order to comply with RF exposure rules.

5.1.4 Antenna Gains for Standalone Operation

To comply with FCC rules relating to maximum RF power and RF Exposure, the maximum antenna gain including cable loss for mobile operation when not co-located with other transmitters must not exceed the following limits..

Band	Antenna Gain
2.5GHz EBS/BRS	8.5dBi

Please refer to the FCC Grant of Certification.

6 Annex 1: PCI Express Mini Edge Connector Pinout

Pin	Name	Pin	Name
51	Reserved	52	+3.3Vaux
49	PCIe - Reserved, rMII - ETH_MDC	50	GND
47	PCIe - Reserved, rMII - ETH_MDIO	48	+1.5V
45	PCIe - Reserved, rMII - ETH_Tx_EN	46	LED_WPAN#
43	GND	44	PCIe - LED_WLAN#, rMII - ADAPTOR_SENSE_2
41	+3.3Vaux	42	LED_WWAN#
39	+3.3Vaux	40	GND
37	GND	38	USB_D+
35	GND	36	USB_D-
33	PCIe - PETp0, rMII - ETH_TXD0	34	GND
31	PCIe - PETn0, rMII - ETH_TXD1	32	SMB_DATA
29	GND	30	SMB_CLK
27	GND	28	+1.5V
25	PCIe - PERp0, rMII - ETH_RXD0	26	GND
23	PCIe - PERn0, rMII - ETH_RXD1	24	+3.3Vaux
21	GND	22	PERST#
19	PCIe - Reserved, rMII - ETH_CLK	20	W_DISABLE#
17	PCIe - Reserved, rMII - ETH_CRS_DIV	18	GND
Mechanical Key			
15	GND	16	PCIe - UIM_VPP, rMII - ADAPTER_SENSE_1
13	REFCLK+	14	UIM_RESET
11	REFCLK-	12	UIM_CLK
9	GND	10	UIM_DATA
7	CLKREQ#	8	UIM_PWR
5	COEX2	6	+1.5V
3	COEX1	4	GND
1	WAKE#	2	+3.3Vaux

Key	
(green)	**PCIe, Used by PEM**
(blue)	**PCIe Unused/PEM ‘For future Use’**
(red)	**Unused**