# DLP® Series-241 DMD and System Mounting Concepts

# Application Report

Literature Number: DLPA034
May 2013

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# *DLP® Series-241 DMD and System Mounting Concepts*

## 1 Scope

This application report serves as an aid to the successful first-time utilization and implementation of the Series-241 DMD (DLP4500FQE) and addresses the following topics:

- Terminology
- Specification and design details of a Series-241 DMD
- System mounting concepts for a Series-241 DMD, including key attributes and important application design considerations
- Connectors for use with a Series-241 DMD

## 2 Terminology

**Mechanical ICD —** The Mechanical Interface Control Drawing (ICD) describes the geometric characteristics of the DMD. This is also referred to as the Package Mechanical Characteristics.

**BTB —** Board-to-Board (BTB) connector; refers to a type of electrical connector that is typically used to provide an electrical connection between two PCBs, or a PCB and an FPCB

**Dark Metal —** The area just outside the active array but within the same plane as the active array, see Figure 5

**DMD Features—** The primary features of the Series-241 DMD are described below and illustrated in Figure 1 and Figure 2

- Bond wires – the wires which electrically connect the WLP DMD chip to the ceramic carrier
- Ceramic Substrate – the structures which form the mechanical, optical, thermal, and electrical interfaces between the WLP DMD chip and the end-application optical assembly
- C-notch – outline feature of the ceramic substrate that is the shape of the letter 'C' (rectangular cutout with filleted corners)
- DMD Chip (or just DMD) – The aggregate of the WLP chip, ceramic substrate, bond wires, encapsulation, and electrical pins
- DMD test pads – pads used by TI to electrically test the DMD during the manufacturing process (do not connect these pads in the system application)
- DMD active array – the two-dimensional array of active DMD mirrors which reflect light
- Encapsulation – the material used to mechanically and environmentally protect the wire bond wires
- System interface connector – the electrical interface between the Ceramic substrate and the end-application electronics
- TI test interface – LGA pads used by TI to electrically test the DMD during the manufacturing process (do not connect these pads in the system application)
- V-notch – outline feature of the ceramic substrate that is the shape of the letter 'V' (cutout)
- Window glass – the clear glass cover which protects the DMD active area (mirrors)
- Window aperture – the dark coating on the inside surface of the window glass around the perimeter of the active array
- WLP chip – Wafer-Level Package (WLP) DMD chip that contains the DMD active array and window glass

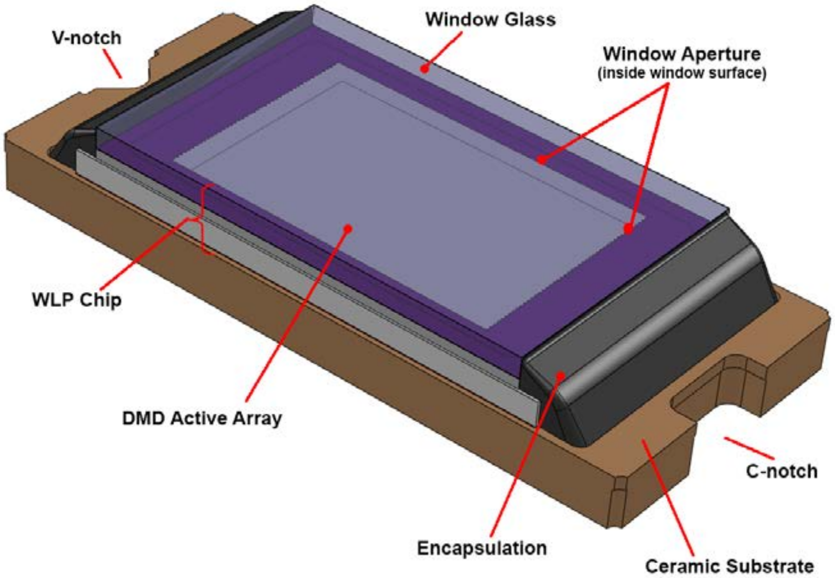


**Figure 1. DMD Features – Window Side**

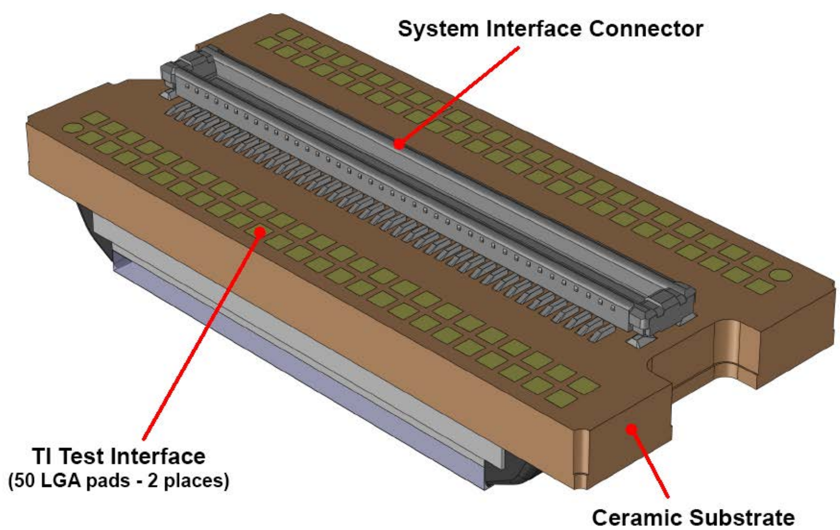


**Figure 2. DMD Features – Electrical Side**

**FPCB—** Flex Printed Circuit Board

**Illumination Light Bundle—** refers to the illumination cross-section area (size) at any location along the illumination light path but specifically at the DMD active array and within the same plane as the active array

**Interposer—** component that provides electrical connection to a DMD which utilizes a land grid array for the system electrical connection (similar to a socket or connector)

**LGA—** Land Grid Array (refers to a two-dimensional array of electrical contact pads)

**Optical Assembly—** The sub-assembly of the end product which consists of optical components and the mechanical parts that support those optical components

**Optical Chassis—** The main mechanical part used in the optical assembly to mount the optical components (DMD, lens, prism, and so forth)

**Optical Illumination Overfill —** The optical energy that falls outside the active area, and which does not contribute to the projected image

**Optical Interface—** Refers to the features on the optical chassis used to align and mount the DMD

**PCB—** Printed Circuit Board

**PGA—** Pin Grid Array (refers to a two-dimensional array of electrical contact pins)

**RSS —** Root Sum Square method of characterizing part tolerance stack-ups. This is the square root of the sum of each part tolerance squared.

**SUM —** Sum method of characterizing part tolerance stack-ups. This is the sum of each part tolerance .

**TP —** Thermal test point

## 3 DMD Specifications

The key mechanical and thermal parameters of the DMD are described in this application note. The actual parameter values are specified in the DMD data sheet. A 3D-CAD file of the DMD nominal geometry of STEP format is available for download. See Section 6.

### *3.1 Optical Interface Features*

To facilitate the physical orientation of the DMD active array relative to other optical components in the optical assembly, the Series-241 DMD incorporates three principle datum features (Datum ‘A’, Datum ‘B’, and Datum ‘C’). The dimensions and sizes of the datum features are defined in the Mechanical ICD drawing at the end of the data sheet. The three datum features are shown in Figure 3 and described below.

Datum ‘A’ – Primary Datum

Datum ‘A’ is a plane specified by 3 areas on the surface of the ceramic substrate. The plane of the DMD active array is parallel to the plane formed by the three Datum ‘A’ areas. The DMD active array has a controlled distance and parallelism from Datum ‘A’, as defined in the Mechanical ICD. Datum ‘A’ allows the plane of the active array to be precisely (and repeatedly) oriented along the system optical axis. The Datum ‘A’ areas are a part of a surface and not a raised separate feature.

Datum ‘B’ – Secondary Datum

Datum ‘B’ is not a feature on the ceramic substrate but rather the center of a theoretically perfect 1.50 mm diameter that contacts tangent points on the edge of the V-notch cutout of the ceramic substrate. The flat sides of the V-notch make a line contact with the theoretical 1.50 mm diameter. While Datum ‘A’ defines the reference location of the active array plane axially along the system optical axis, Datum ‘B’ establishes the reference for the X and Y position of the active array within the Datum ‘A’ plane. Datum ‘B’ is not the entire depth of the V-notch in the ceramic but rather the top region closest to the Datum ‘A’ areas, see Figure 3.

Datum ‘C’ – Tertiary Datum

Datum ‘C’ is the one edge of a 3.0-mm wide C-shaped cutout on the edge of the ceramic substrate. The Datum ‘C’ edge is specified in the Mechanical ICD. Datum ‘C’ establishes the reference rotation of the active array within the Datum ‘A’ plane and about the Datum ‘B’ X-Y reference position. The Datum ‘C’ is not the entire depth of the C-shaped notch in the ceramic but rather the top region closest to the Datum ‘A’ areas, see Figure 3. Note that Datum ‘C’ is not the center of the C-shaped notch.

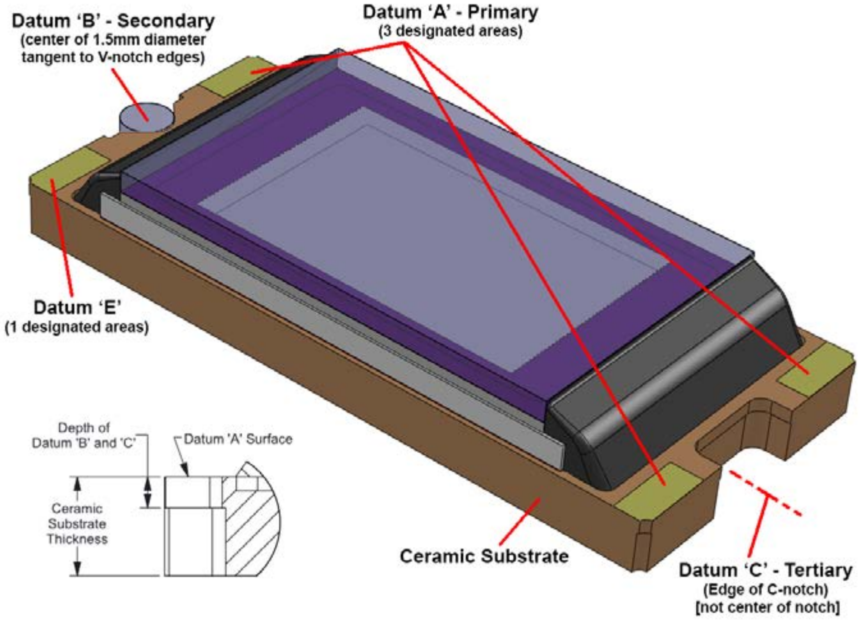


**Figure 3. DMD Datum Features**

### 3.2 DMD Cross Section Features

Figure 4 illustrates the features of the DMD in cross-section. Shown are the window thickness, distance from active array to the window, window aperture location, ceramic substrate thickness, Datum 'A' plane location, active array plane, and encapsulation. The nominal distance and tolerance between these features are defined in the DMD Mechanical ICD.

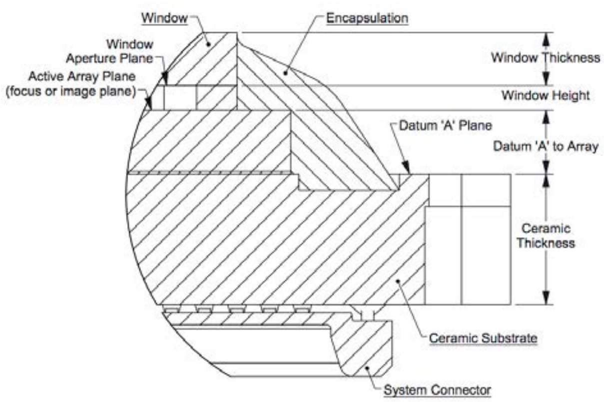


**Figure 4. DMD Cross Section View Features**

### 3.3 Optical Illumination Overfill

Optical illumination overfill is defined as the optical energy that falls outside the active area. The overfill is wasted light and does not contribute to the brightness of a projected image. The shape and spatial distribution of the optical energy in the overfill region is determined by the system optical design. The overfill which results from an example illumination profile is illustrated in Figure 5.

Typical attributes that result in different overfill profiles include (but are not limited to) integrator size, illumination source, and optical aberrations (such as distortion and/or color separation).

Excess optical illumination overfill can result in higher thermal loads on the DMD (which must be cooled by the system) and/or various types of image artifacts (for example, stray light).

The magnitude of these effects depends upon several factors which include (but are not limited to):

- The total amount of energy being reflected from the DMD active array
- The total amount of energy within the overfill area
- The spatial distribution of energy within the overfill area
- The specific DMD feature upon which overfill is incident (window aperture, dark metal area around the active array which is in the plane of the array plane, and so forth)
- The thermal management system used to cool the DMD
- The type of end-application (for example, front projection display, rear projection display, lithography, measurement, printing, and so forth)

The amount of energy outside the active array should be minimized to improve system optical efficiency, reduce the thermal cooling load, and reduce any possible optical artifacts.

Optical overfill energy on the window aperture (if present) should especially be avoided. The heat absorbed by the window aperture (due to overfill that is incident upon the window aperture) is more difficult to remove (more resistive thermal path) than heat absorbed in the dark metal area surrounding the active array.

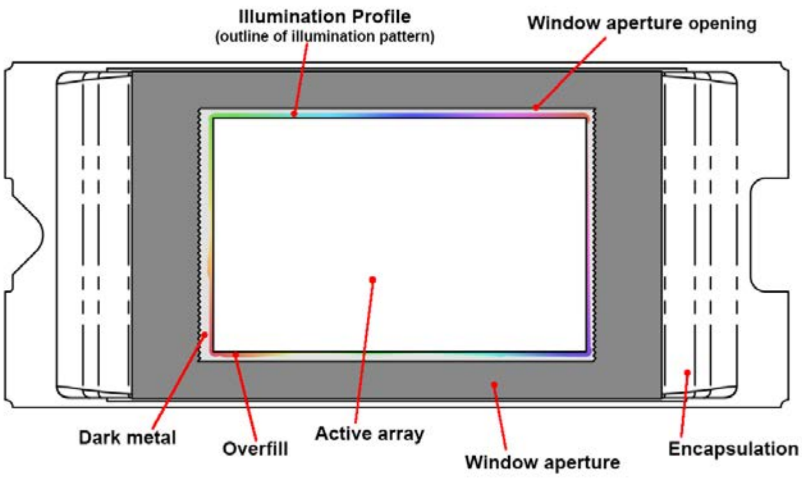


**Figure 5. Optical Illumination Overfill**

## 3.4 System Dust Gasket and System Aperture

The exterior surface of the DMD window is relatively close to the imaging plane of the DMD active array, as shown in Figure 4. Since the DMD active array is the optical focus plane, there is a risk of dust particles on the outside window surface being re-imaged and appearing in the projected image. To prevent this from occurring it is best to prevent dust from getting onto the outside surface of the DMD window. This can be accomplished by:

- Not having any openings in the optics assembly (close openings, use of gaskets, tape, and so forth)
- Maintaining optical cleanliness for all components used in the optical assembly, including the mechanical parts
- Assemble in a clean room environment

It is import that any gasket be flexible (compressive) enough that it does not interfere with the contact between the DMD Datum ‘A’ features, and the associated features on the optical chassis. Such interference could result in optical focus uniformity issues.

### 3.5 Active Array Size and Location

The active array size and location is specified in the DMD data sheet The active array is located relative to the specified DMD Datum ‘A’, Datum ‘B’ (1.50 diameter), and Datum ‘C’ (center of C-notch) features.

The active array center is not at the center point between Datum ‘B’, and Datum ‘C’, but rather offset top-to-bottom. The offset is illustrated in Figure 6.

Also, the active array center is not centered between the 0.6-mm radius of the V-notch and the edge of the C-notch, nor is it centered between the Datum ‘B’ and the C-notch edge. This is illustrated in Figure 6 and Figure 7. Note the center of the V-notch radius and center of Datum ‘B’ are not coincident, see Figure 7.

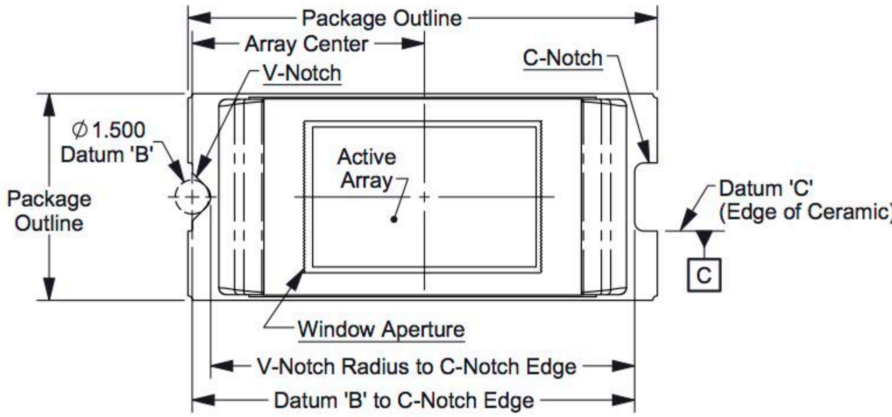


**Figure 6. Active Array Location**

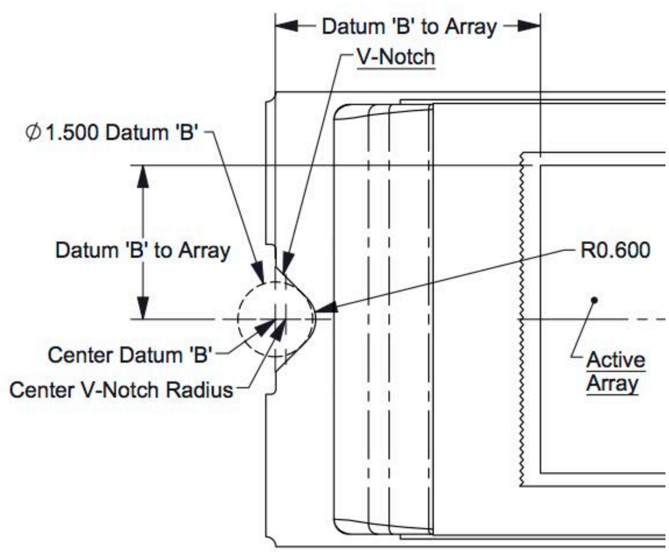


**Figure 7. Active Array Location and V-notch Detail**

### 3.6 Electrical Interface Features

The electrical interface to the Series-241 DMD is a Board-to-Board connector. See Section 5 for connector details. The pin numbering scheme for the BTB connector used on Series-241 DMDs is illustrated in Figure 8. The signal names for each pin C1 – C40 and D1 – D40 are identified in the DMD data sheet.

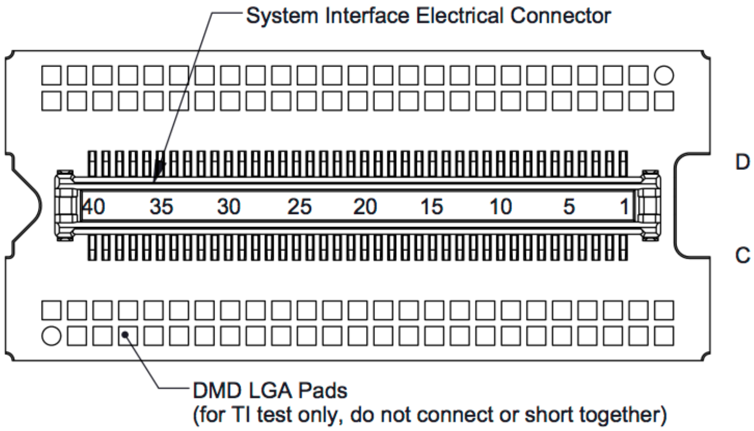


**Figure 8. Pin Numbering Scheme**

The LGA pads surrounding the BTB connector are reserved for testing during the manufacture of the DMD and are not to be electrically connected in the system. Care should be taken when mounting the DMD to ensure the LGA pads are not shorted together as this will cause the DMD to not function properly or be damaged.

## *3.7 Thermal Considerations*

The Series-241 DMD does not have a dedicated thermal interface area. This is generally not an issue, as the DMD is intended for applications with low thermal loads from the illumination source.

The primary thermal load on the DMD originates from the dissipated electrical load that drives the mirrors and the absorbed optical load. Secondary heating from other components near the DMD can exist, but their significance depends upon the magnitude and location relative to the DMD. Secondary heating sources could be electrical components near the DMD (convective transfer of heat) or mounted to the same optical chassis as the DMD (conductive transfer of heat). The transfer of heat from secondary heating sources to the DMD should be eliminated or at least minimized.

Note that optical energy that falls on the window aperture is wasted energy that must be cooled, but does not contribute to the optical efficiency of the DMD. The energy on the window aperture is the most challenging to dissipate from the DMD and should be eliminated or reduced as much as possible.

Please see the DMD Data Sheet for additional thermal information. The thermal specifications provided in the DMD data sheets are based upon characterizations done with illumination loads which are evenly distributed across the active array with less than 16% overfill (by energy). Applications utilizing illumination profiles which have regions of high energy density (for example, highly collimated laser beams) have not been characterized and require special consideration on the part of the product designer.

## *3.8 Mechanical Loading Considerations*

Installing a DMD into an end-application environment will involve placing a mechanical load on the DMD, and (more specifically) upon the ceramic substrate. The maximum mechanical load which can be applied to the DMD is specified in the DMD data sheet. The areas the loads are to be distributed are shown in Figure 9. The load is the maximum to be applied during the installation process, or the continuous load after the DMD has been installed. The DMD has three main areas to accommodate a mechanical load:

Connector Area

The Series-241 DMD is designed to accommodate mechanical loads evenly distributed across the connector area. Load on this area is associated with the insertion of the connectors to make electrical connection, and that which is continuously applied to ensure proper electrical connection is maintained.

DMD Mounting Area

The Series-241 DMD is designed to accommodate mechanical loads evenly distributed across each of the three areas shown in Figure 9. These areas are on the opposite side of the ceramic from the Datum ‘A’ areas. Load on this area is associated with mounting and securing the DMD into the optical engine.

Datum ‘A’ Area

The Series-241 DMD will accommodate a mechanical load evenly distributed across the three Datum ‘A’ areas shown in Figure 9. This load functions to counteract the combined loads from the thermal and the electrical interface areas. The Mechanical ICD defines the location and size of the Datum 'A' areas.

The Data Sheet specifies three Datum ‘A’ areas based on the fact that three points define a plane. These three points are what the active array plane is referenced. From a practical standpoint the mounting and securing of the DMD is simpler and more consistent if four areas are contacted rather than three. This reduces the chance of tilting the DMD during mounting when a non-uniform clamping load is applied. In the case where four areas are used, the maximum load for the ‘DMD mounting area’ should be uniformly distributed across the four areas. The four mounting areas shown in Figure 9 are those on the opposite side of the ceramic from the Datum ‘A’ areas and Datum ‘E’ area.

Loads in excess of the specified limits can result in mechanical failure of the DMD package. A failure may not be catastrophic such that it can be initially identified but rather a more subtle failure, which could result in reduced lifetime of the DMD.

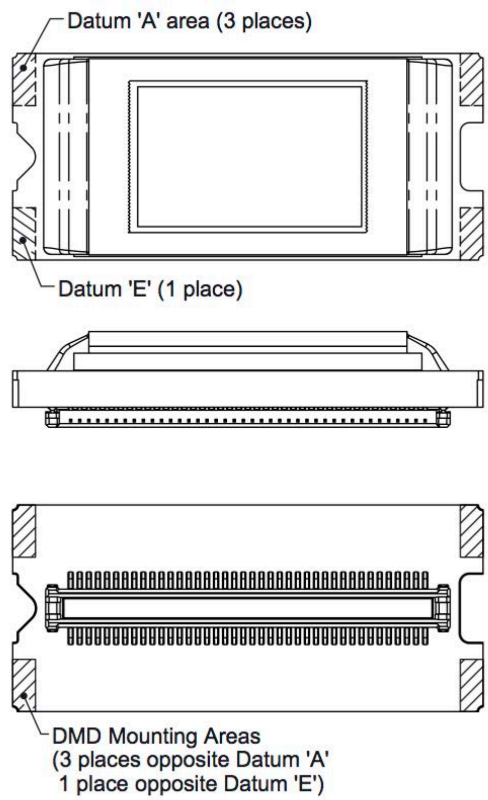


**Figure 9. DMD Mechanical Loads**

# 4 System DMD Mounting

## 4.1 Critical Considerations for Mounting the DMD

The method used to mount the DMD into the end-application system needs to meet the functional design objectives of the application, while also ensuring that the DMD thermal and mechanical specifications are not exceeded.

The functional design objectives of the mounting system include:

- Establish (and maintain) the physical placement of the DMD's active array relative to the optical axis of the applications optical assembly
- Establish (and maintain) a proper electrical connection between the DMD's electrical interface and the system connector
- Establish (and maintain) a dust-proof seal between the DMD and the chassis of the optical assembly
- Establish (and maintain) a proper thermal connection between the DMD's thermal interface area and the system's thermal solution. Systems with low thermal loads on the DMD will generally not need a dedicated thermal connector

To meet these functional design objectives requires that some minimum mechanical load be applied to the DMD. The DMD mounting concepts presented in this application note achieve the minimum mechanical load to meet the functional objectives while illustrating various concepts for controlling the maximum mechanical loads being applied to the DMD.

The ideal design is one which:

- does not rely upon strict assembly techniques or processes
- is tolerant of manufacturing variations of piece parts
- minimizes the variations in mechanical loads applied to the DMD

If not understood and minimized, the variations can easily result in lower forces than what is needed to hold the DMD in place, or higher forces which could result in damage to the DMD.

## 4.2 Basic System DMD Mounting Concept

The DMD mounting concepts described in this application note represent “drop-in-place“ designs. The “drop-in-place” name indicates that the DMD is placed onto the optical chassis mounting features and secured into place without any adjustment for the optical alignment of the DMD. A drop-in-place” design is desirable because it simplifies the assembly process of the DMD. Achieving a “drop-in-place” design is realistic for a single-chip DMD system. Achieving a “drop-in-place” design for a multi-DMD system is more challenging, due to the need to align the individual DMD's to each other in order to form a single combined image.

Most often when using a “drop-in-place” mounting concept, the illumination light bundle still needs to be aligned to the DMD active array. Generally the illumination light bundle is adjusted to align it to the DMD after the DMD is installed into the system. A convenient way to perform this adjustment is by adjusting an integrator element or fold mirror.

A “drop-in-place” style of mounting simplifies the assembly of the DMD into the optical assembly, but requires adequate tolerances on the DMD interface features of the optical chassis (see Section 4.2.1). The specific tolerance requirements vary for each system design. Key areas of consideration include:

- alignment of the illumination light bundle to the active array (X-axis, Y-axis, and rotation)
- size and location of the illumination overfill
- uniform focus across the entire active array
- variation in the location (and rotation) of the active array relative to the illumination light bundle due to size and location tolerances of the DMD mounting features (optical interface) on the optical chassis (this is less critical if DMD interchangeability is not important)
- variation in the location (and rotation) of the active array within the DMD package due to size and location tolerances of the DMD datum features, and the placement of the active array relative to the datum features (this is less critical if interchangeability of DMDs is not important)

Alignment of the illumination light bundle to the active array, the overfill size, and light bundle location are interrelated. The illumination alignment range needs to comprehend the overfill size and dimensional tolerance of the piece parts. Adjustment of the illumination is usually required unless an excessive amount of overfill is used. Note that excessive overfill increases the amount of DMD cooling required and reduces the efficiency of the system (both optical efficiency and electrical power efficiency). For these considerations it is nearly always best to minimize the amount of overfill (size) and to design the system and process with alignment in mind.

A key characteristic of the “drop-in-place” mounting concept is that the planarity of the DMD (active array perpendicular to the projection lens axis) does not need to be adjusted in order to achieve acceptable focus across the entire active array. The depth-of-focus of the optical design is critical to achieving acceptable focus. Key considerations when determining the depth-of-focus required by the optical design include:

- the angular relationship between the DMD Datum ‘A’ mounting areas, the corresponding Datum ‘A’ areas on the optical chassis, and the features used to mount the projection lens (optical axis) to the optical chassis. Typically this translates to a parallelism or perpendicularity between the indicated surfaces depending on the specific optical design
- parallelism of the DMD active array to the three Datum ‘A’ areas

### 4.2.1 Optical-Mechanical Alignment Features

The DMD Optical-Mechanical Alignment Features (datums) are used to establish and maintain the physical placement of the DMD’s active array relative to the illumination light bundle and the optical axis of the projection lens. Section 3.1 reviewed the Optical Interface Features of the DMD. This section reviews the suggested corresponding features on the optical chassis. The features shown in Figure 10 are summarized below:

- Datum ‘A’ & 'E' tabs - four coplanar areas that contact the DMD Datum ‘A’ areas and Datum 'E' area. These establish the relationship for the position of the active array relative to the projection lens axis and other optical components.
- Datum ‘B’ 1.5-mm round pin – contacts with the DMD Datum ‘B’ (V-notch feature) providing two contact areas (line) on the edge of the ceramic
- Datum ‘C’ post – mates with the DMD Datum ‘C’ (C-notch feature). Datum 'C' is the edge of the post, not the center of post
- Threaded holes to mount a clamp or bracket, and secure the DMD against the Datum ’A’ and ‘E’ features of the system optical chassis

The alignment features on the optical chassis are commonly referred to as the optical interface

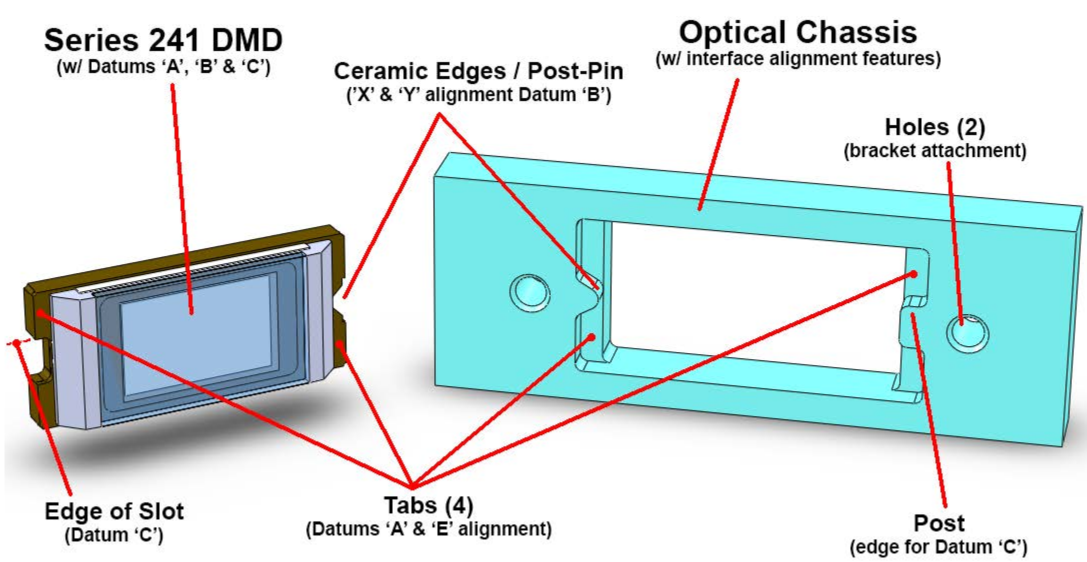


**Figure 10. Optical Interface (Alignment) Features**

The following characteristics of the Series-241 Optical-Mechanical alignment features should be noted:

- The simplest form for the Datum ‘B’ interface feature is a precision 1.5-mm diameter pin. This works fine, however, other shapes could be used to create a more robust feature that would be easier to manufacture. An example of such a feature is shown in Figure 10.
- The three Datum ‘A’ tabs and Datum ‘E’ tab on the optical chassis must be coplanar to ensure uniform focus of the active array, and focus repeatability between systems. The coplanarity of these features and the DMD parallelism combine to determine the requirements for the depth-of-focus for the optical system.
- The outline shape of the features on the optical chassis that correspond and contact the DMD Datum ‘A’ features should be slightly smaller than the defined DMD Datum ‘A’ features to ensure the area outside the DMD Datum ‘A’ area is not contacted. Contact outside of the DMD Datum ‘A’ area could result in focus variations or non-uniform focus.
- A system gasket or aperture (if used) should be designed to not interfere with the proper mating of the DMD Datums and corresponding Datum ‘A’ features on the optical chassis. Any gasket or aperture material that overlaps the DMD Datum ‘A’ features could cause focus problems. Another issue that could result in focus problems is if the gasket material is not compliant enough to allow sufficient compression, thus prohibiting full contact of all the Datum ‘A’ features.
- Avoid sharp edges on the Datum ‘A’ tab features in order to prevent damage to the DMD ceramic substrate. The sharp contact point of a feature edge could result in a highly concentrated load (in a very small area), and potentially lead to damaging (cracking) the DMD’s ceramic substrate.
- The **opening features in the optical chassis should accommodate the maximum encapsulation size** defined in the DMD mechanical ICD drawing. A 3D-CAD model of the DMD is available that has the maximum encapsulation size, see Section 6.
- When mounted, the DMD needs to be held firmly against the DMD Datum ‘A’ and ‘E’ areas. This will prevent the DMD from shifting or moving position. The clamping of the DMD should be done in a manner that does not apply excessive mechanical loads to the DMD. The maximum mechanical loads for the DMD are described in Section 3.8. It can be challenging to control the mechanical load on DMD by control of the torque of the DMD mounting screws. It is also beneficial to minimize clearance gaps between the optical chassis and clamp or bracket to prevent bending of the clamp or bracket when the screws are torqued. Reducing the bending reduces the variation of clamping force. The critical clearance gaps are identified in Figure 11and Figure 12 for two mounting concepts. These mounting concepts will be described in more detail the next sections.

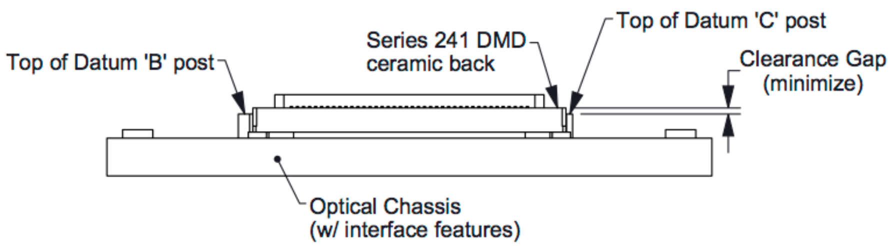


**Figure 11. Mounting Clearance**

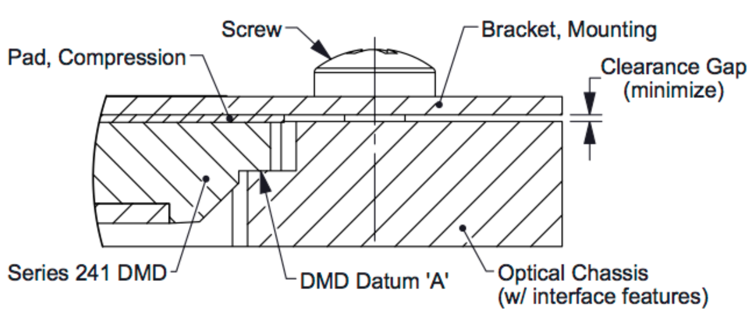


**Figure 12. Mounting Clearance**

- To avoid bending and damaging the DMD, the mounting forces should be applied perpendicular to the substrate and directly opposite the ceramic Datum ‘A’ and ‘E’ areas.
- The DMD V-notch Datum ‘B’ is not a closed feature in the ceramic substrate. The intended use of Datum ‘B’ when mounting the DMD requires the DMD Datum ‘B’ contact the corresponding Datum ‘B’ post on the optical interface. To achieve this, the DMD must be pushed towards the Datum ‘B’ post in the direction illustrated in Figure 13, and clamped in place at this location.
- The DMD Datum ‘C’ is the edge of the C-shaped notch in the ceramic substrate. The datum is not the center of the C-shaped notch. The intended use of the Datum ‘C’ when mounting the DMD requires the DMD Datum ‘C’ contact a corresponding feature on the optical interface. To achieve this, the DMD must be pushed towards the interface Datum ‘C’ feature in the direction illustrated in Figure 13.
- Utilizing the DMD Datums ‘B’ and ‘C’, as described above and illustrated in Figure 13, when mounting the DMD will reduce X-Y movement and rotation variation of the DMD.

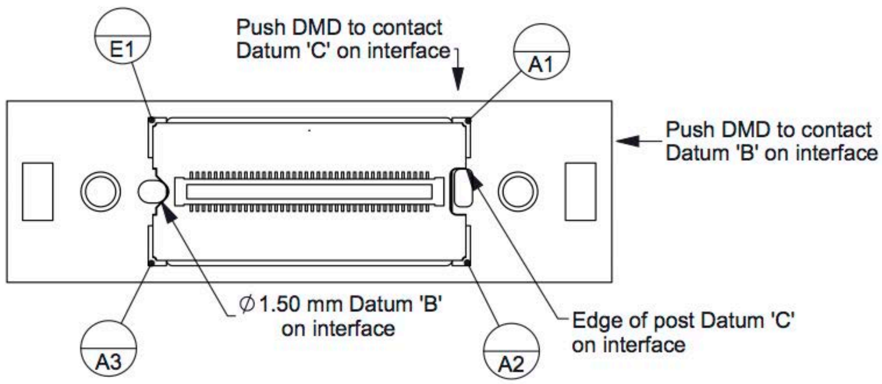


**Figure 13. Mounting Datum 'B' Contact**

### 4.2.2 Heat Sink Mounting

The Series-241 DMD does not have a dedicated thermal interface area to aid in thermal cooling. If a heat sink is needed to ensure the DMD thermal requirements are met, the heat sink could be incorporated into the clamp or bracket used to mount the DMD.

The areas adjacent to the system interface connector could be contacted and used to help with cooling the DMD. If this is done, the material contacting the electrical pads in this area are not shorted together.

### 4.2.3 Dust Gasket

The dust gasket (if incorporated) functions to provide a barrier to prevent ambient dust particles from accumulating on the DMD window glass. The outside window surface is relatively near the image plane (active array) of the DMD. The cross-section view of the DMD shown in Figure 4 illustrates this close proximity.

Dust particles on the DMD window, if large enough, could appear in the projected image as shadows or near shadows.

Characteristics of a dust gasket should include:

- creates no interference with the DMD mounting features (Datum ‘A’, ‘B’, and ‘C’) on the optical chassis when in either the compressed or non-compressed state
- has sufficient compliance to allow necessary compression without a significant mechanical mounting load on the DMD
- creates a sufficient seal against the surfaces it contacts to prevent dust particles from reaching the DMD window glass
- comprised of a material which does not create particles
- comprised of a material which does not allow dust particles to pass through its volume
- gasket should not interfere with assembly of the DMD into the optical assembly

### 4.3 Detailed DMD Mounting Concept

Detailed concepts for mounting the DMD that will meet the needs stated earlier are described in this section. Two concepts of aligning the DMD are illustrated. One concept utilizes shims and the other features in a clamp to facilitate alignment of the DMD into the optical interface.

It is expected that the parts and features represented in the these concept designs will be adapted or modified to accommodate a specific application, part design requirements, part manufacture requirements, part manufacturing tolerances, and other customer needs.

#### 4.3.1 Shim Alignment Mounting Concept

The design concept for mounting the Series-241 DMD shown in Figure 14 is a "drop-in-place" concept which incorporates specific features in the interface and the use of shims to aid DMD alignment during the DMD installation process. The function of the bracket is to hold the DMD in place and, in doing so, apply mechanical loads to the DMD.

The drawing number for the "Edge Guide" mounting concept assembly shown in Figure 14 is 2513190. The 3D-CAD models (in STEP format) and drawings (in pdf format) for each of the parts shown are available for download. See Section 6.

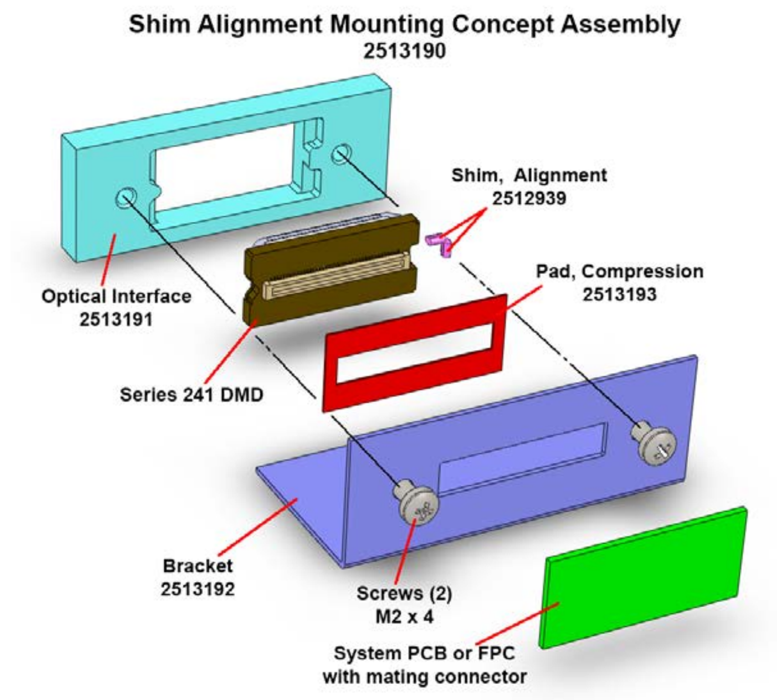


**Figure 14. Clamp Alignment Mounting Concept**

##### *4.3.1.1 Shim Alignment Features*

Consistent and repeatable location of the active array requires the DMD be manually pushed into contact with the optical interface Datums ‘B’ and ‘C’ features, and then held in place while the mounting screws are tightened. To facilitate holding the DMD in position, this mounting concept utilizes two shims. The function of the shims is to keep the DMD from shifting locations while the bracket is secured. After the bracket is secured the shims are not needed. The shims are a compressible material that is wedged between the optical interface and the DMD. The shims and Datum features are shown in Figure 15.

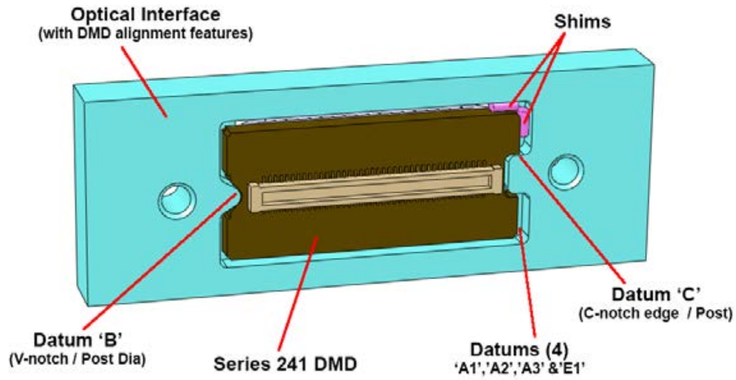


**Figure 15. Alignment Shims**

The gap between the optical interface and DMD varies with the interface and DMD size (manufacturing tolerances). The gaps and shim locations are shown in Figure 16. The size of the gap should be adjusted to accommodate:

- Optical interface opening size variations
- DMD size variation
- Size and shape of the shim part
- Compressibility of materials available for the shim part
- Forces needed to hold the DMD in position against Datums 'B' and 'C'

The shape of the shim in this concept is round but could be any shape. Round shapes seem readily available in many sizes and materials, and are easily installed. When compressed in the gap, the round shape of the shim increases size (height) in one direction, as illustrated in Figure 16. The shim material and gap size should be determined so the amount of increase does not interfere with the bracket or DMD installation.

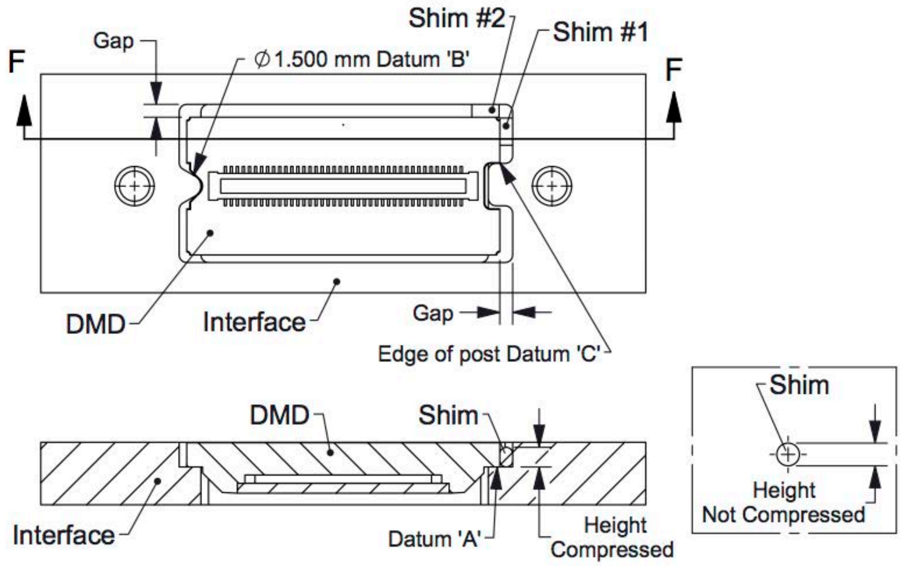


**Figure 16. Gaps and Shim Shape**

#### 4.3.1.2 Mechanical Load Control

This mounting concept design is simple and has a limited number of parts. This concept includes a flexible or compliant part (compression pad) that absorbs the part manufacturing variations or part tolerances. When installing the DMD into the optical chassis, ensure the mechanical loads applied to the DMD do not exceed the DMD specification. The compression pad characteristics, screw torque, and assembly procedure combine to determine the loads applied to the DMD. A summary of considerations to avoid excessive mechanical loads on the DMD include:

- Compression pad force versus deflection characteristics
- Tolerances of the critical dimension on the optical interface to minimize the gap between the interface and the bracket. This clearance gap is illustrated in Figure 17
- Controlling the torque on the screws
- Partially tighten both screws prior to final tightening
- Use alternating order when tightening the screws for both partial and final torque

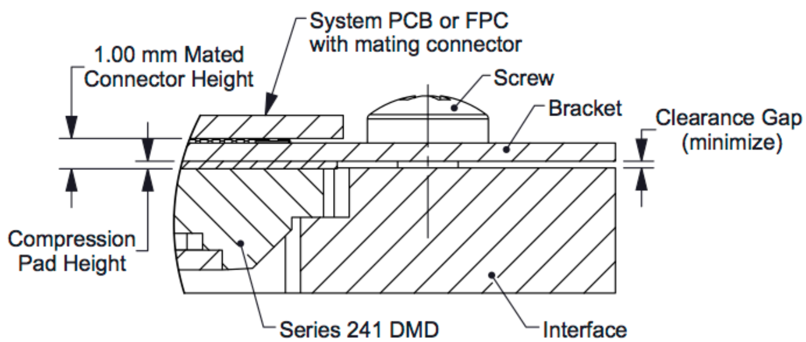


**Figure 17. Critical Gap for Control of Load**

The use of torque on the screws to control the forces applied to the DMD is highly dependent on the interface material, screw material, type of screw (thread forming or machine), and friction factor between the of screw threads and optical interface. Generally, the force on the DMD will vary widely because of these. The bracket will usually bow until the bracket contacts the interface. Minimizing the clearance gap between the bracket and interface helps to reduce the chances of applying excess forces to the DMD but does not guarantee it. The clearance gap is shown in Figure 17.

An analysis of the gap between the bracket and the interface will identify the potential amount the bracket could bend. Figure 18 illustrates the key part features and a schematic of the tolerances. The tolerance schematic starts at the bracket, continues to the pad, the DMD, and concludes at the interface (on the right-hand side of the figure).

The nominal, minimum, and maximum gap sizes for this design are shown in Table 1 for both a SUM and RSS tolerance analysis method. The nominal gap (no tolerance variation) is 0.220 mm. The gap could be as small as 0.03 or as large as 0.41 mm for the SUM analysis method (worst case). The gap range is 0.101 mm to 0.339 mm for RSS analysis method. The actual gap size will depend on the compression pads force versus deflection characteristics.

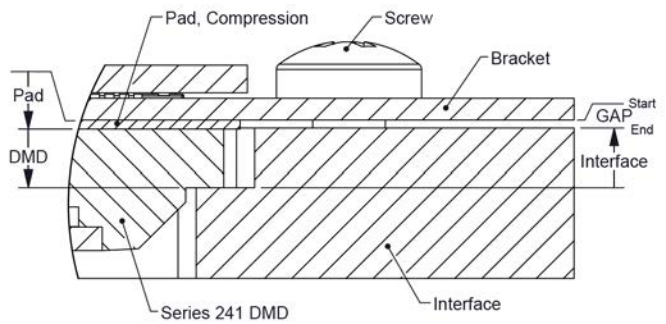


**Figure 18. Gap Tolerance Analysis Schematic**

**Table 1. Analysis of Gap Between Interface and Bracket**

| | Nominal (mm) | Direction Sign | Nominal (mm) | Tol (±) (mm) | Tolerance Method | Gap (2) | |
|---|---|---|---|---|---|---|---|
| Pad | 0.250 | –1 | –0.250 | 0.050 | | | |
| DMD | 1.600 | –1 | –1.600 | 0.100 | | | |
| Interface | 1.630 | 1 | 1.630 | 0.040 | | | |
| | | | | | | **Max GAP** | **Min GAP** |
| SUM | | | –0.220 | 0.190 | **SUM** | –0.030 | –0.410 |
| | | | (1) | 0.119 | **RSS** | –0.101 | –0.339 |

(1) Nominal value must be negative to have a gap between interface and bracket.

(2) The gap is the potential amount the bracket would need to move (from tightening the screws) before the bracket contacts the interface. The amount the bracket moves depends on the clamping force of the screws and the force deflection characteristics of the compression pad.

This concept is an example of mounting the DMD. Specific requirements like size or other geometry configuration associated with a specific implementation may require alternate designs for a final product. Space available and the control of the loads on the DMD should be critical considerations

#### *4.3.1.3 Mating PCB or FPCB*

This concept requires the PCB or FPBC that connects the DMD to fit between the bracket mounting screws. The mated connector height for the connector pair is 1.0 mm. If the PCB or FPCB overhangs the mounting screws, adjustments will need to be made to accommodate this.

Ensure the bracket thickness, compressed height of the compression pad, and bending of the bracket do not interfere with the proper engagement of the DMD and system connectors. The 1.0 mm mated height between the DMD and PCB (or FPCB) is shown in Table 1.

#### *4.3.1.4 Thermal Consideration*

For applications that have higher illumination energy, the dissipation of the absorbed energy from the DMD becomes more important. The DMD does not have a dedicated area to aid in cooling the DMD but does have small areas on each side of the system interface connector that can be contacted to help remove the absorbed energy.

The main purpose of the mounting bracket is to hold the DMD in position. The bracket for this option incorporates an area that supports cooling of the DMD. This is shown in Figure 19. The size and shape are flexible to accommodate the surface area needed for the amount of available air flow, and the other parts near the DMD.

Considerations for the bracket include:

- Thermal conductivity of material
- Stiffness of the material to reduce bending and interfering with the connector mating

- Features to increase stiffness can be included in the bracket design
- Maximum material thickness that will not interfere with connector mating

For maximum heat transfer to the bracket from the DMD the compression pad should be made of a thermally conductive material. The compression pad material must not be made of electrically conductive material to avoid shorting the test pad signals together.

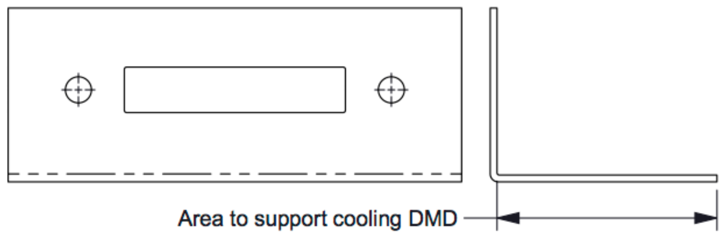


**Figure 19. Mounting Bracket Thermal Consideration**

### 4.3.2 Clamp Alignment Mounting Concept

The design concept for mounting the Series-241 DMD shown in Figure 20 is a "drop-in-place" concept which incorporates specific features in the clamp to aid DMD alignment during the DMD installation process.

The drawing number for the clamp alignment mounting concept shown in Figure 20 is 2511460. The 3D-CAD models (in STEP format) and drawings (in pdf format) for each part shown are available for download, see Section 6 .

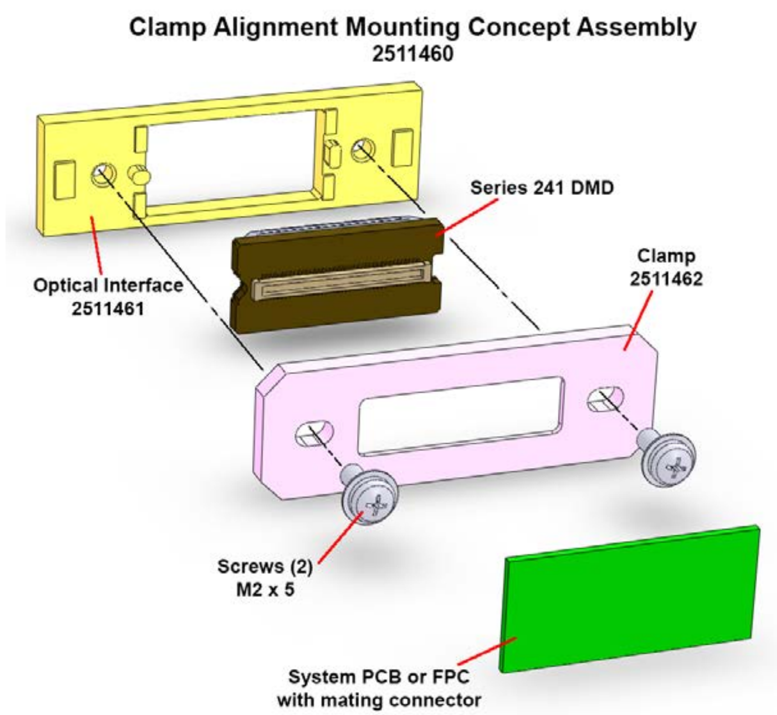


**Figure 20. Clamp Alignment Mounting Concept**

#### 4.3.2.1 Clamp Alignment Features

Consistent and repeatable location of the active array requires the DMD be manually pushed into contact with the optical interface Datums ‘B’ and ‘C’ and then held in place while the mounting screws are tightened. This concept design includes clamp features to help facilitate movement of the DMD to contact the interface Datums. The direction of the clamp movement is shown in Figure 21. Other clamp designs are possible, which could automatically push the DMD to contact the interface Datums ‘B’ and ‘C’ but are not covered in this document.

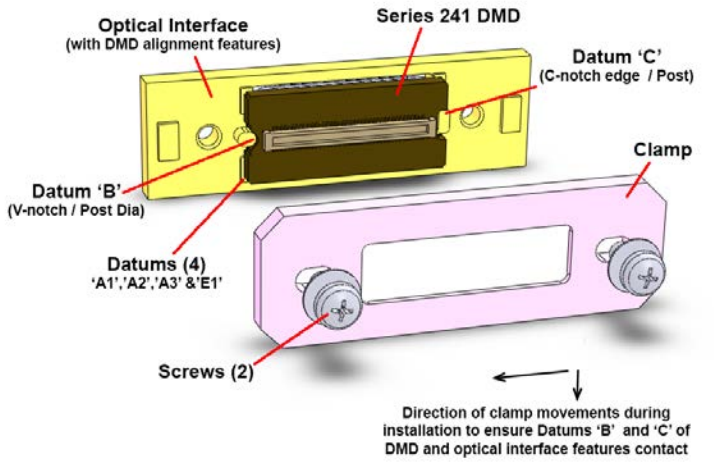


**Figure 21. Clamp Movement**

Figure 22 and Figure 23 illustrate the clamp features which contact the DMD sides opposite Datums ‘B’ and ‘C’. These features facilitate the movement of the clamp so the DMD contacts the interface Datum ‘B’ and ‘C’.

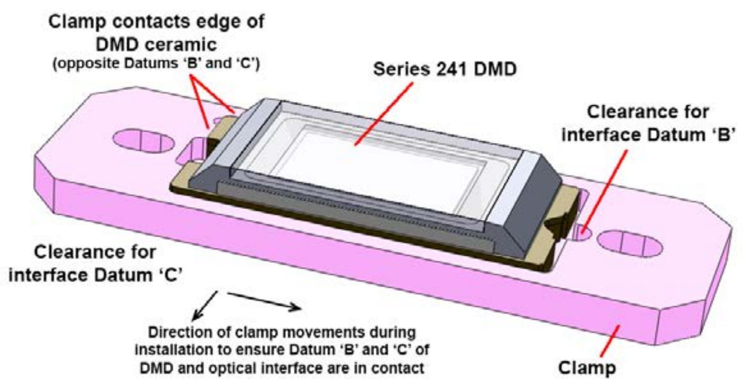


**Figure 22. Clamp Contact on DMD Edge**

The clamp design incorporates raised features that correspond to areas on the side of the DMD ceramic, opposite the Datum ‘A’ areas. The raised areas are shown in Figure 23. The use of the raised areas helps to ensure the mounting load on the DMD is applied to the Datum ‘A’ and ‘E’ areas of the DMD. The selection of the material and finish of the clamp should be such that the LGA test pads or BTB connector leads are not electrically connected or shorted together.

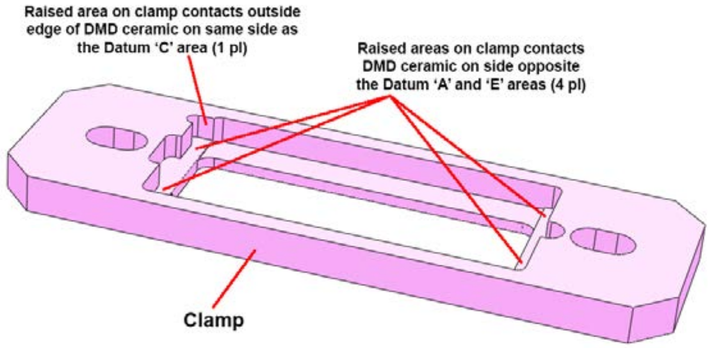


**Figure 23. Clamp Datum 'A' and 'E' Contact**

### *4.3.2.2 Mechanical Load Control*

This mounting concept design is simple and has the fewest number of parts. This concept does not include a flexible feature or compliant part like a spring to absorb the part manufacturing variations or part tolerances. When installing the DMD to the optical chassis using the two screws, ensure that the loads applied to the DMD by tightening the screws do not exceed the DMD specification. The control of the loads applied to the DMD must be done by a combination of part tolerances and assembly processes. A summary of these is below:

- Tolerances of the critical dimension on the optical interface and clamp to minimize the gap between the threaded boss and the clamp. This gap is illustrated in Figure 24
- Controlling the torque on the screws
- Partially tighten both screws, prior to final tightening
- Use alternating order when tightening the screws for both partial and final torque

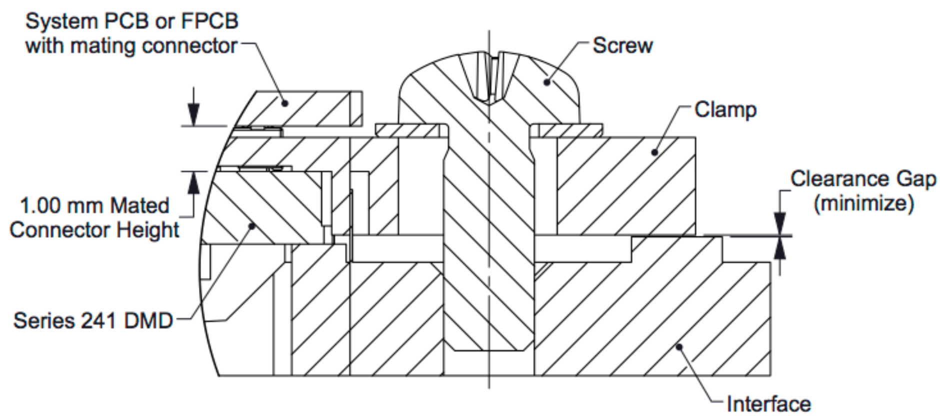


**Figure 24. Critical Gap for Control of Load**

The use of torque on the screws to control the forces applied to the DMD is highly dependent on the interface material, screw material, type of screw (thread forming or machine), friction factor between the screw threads, and optical interface. Generally, the force on the DMD will vary widely because of these. The clamp will usually bow until the clamp contacts the optical chassis interface. Minimizing the gap between the clamp and interface helps to reduce the chances of applying excess forces to the DMD but does not guarantee it. The clearance gap is shown in Figure 24.

An analysis of the gap between the clamp and the interface (raised area) will identify the potential amount of clamp bending that could occur. Figure 25 illustrates the key part features and a schematic of the tolerances. The tolerance schematic starts at the clamp, continues to the DMD (on the right-hand side of the figure), and concludes at the interface raised area.

The nominal, minimum, and maximum gap sizes for this design are shown in Table 2, for both a SUM and RSS tolerance analysis method. The nominal gap (no tolerance variation) is 0.04 mm. This shows the gap could be as small as zero or as large as 0.26 mm for the SUM analysis method (worst case).

For the case where the gap is zero, the potential exists for a gap to develop between the DMD and clamp. This gap could be as large as 0.18 mm for the SUM analysis method. The gap is not likely if the clamp bends a small amount. The placement of the raised area on the interface (outside of the screw clamping area) will enable the clamping force of the screw to bend the clamp and close the gap. The height of the raised area could be adjusted to accommodate the stiffness of the clamp and amount of bending.

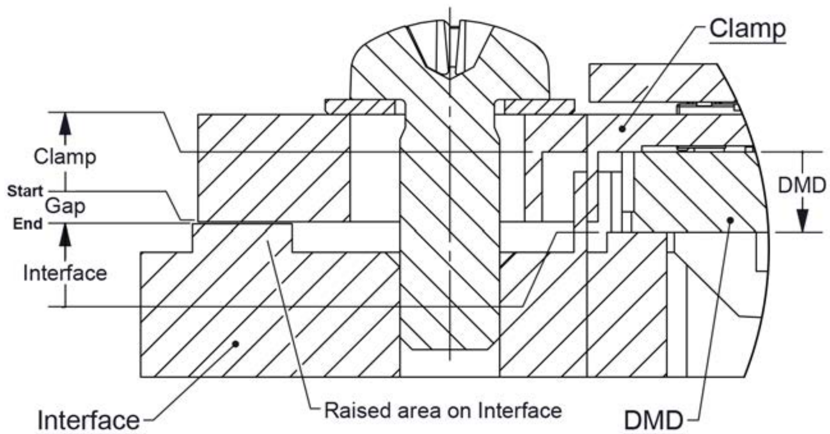


**Figure 25. Gap Tolerance Analysis Schematic**

**Table 2. Analysis of Gap Between Interface Raised Area and Clamp**

| | Nominal (mm) | Direction Sign | Nominal (mm) | Tol (±) (mm) | Tolerance Method | Gap | |
|---|---|---|---|---|---|---|---|
| | | | | | | Max GAP (2) | Min GAP |
| Clamp | 1.400 | 1 | 1.400 | 0.080 | | 0.000 | |
| DMD | 1.600 | –1 | –1.600 | 0.100 | | | |
| Interface | 0.160 | 1 | 0.160 | 0.040 | | | |
| SUM | | | –0.040 | 0.220 | **SUM** | 0.180 | –0.260 |
| | | | (1) | 0.134 | **RSS** | 0.094 | –0.174 |
| (1) Nominal value must be negative to have a gap between clamp and interface | | | | | | | |
| (2) Minimum gap is zero - value is potential gap between DMD and Clamp. | | | | | | | |

This concept is an example of mounting the DMD. Specific requirements like size or other geometry configuration associated with a specific implementation may require alternate designs for a final product. Space available and the control of the loads on the DMD should be critical considerations.

### *4.3.2.3 Mating PCB or FPCB*

This concept requires the PCB or FPBC that connects the DMD to fit between the bracket mounting screws. The mated connector height for the connector pair is 1.0 mm. If the PCB or FPCB overhangs the mounting screws adjustments, will need to be made to accommodate this.

Ensure the clamp thickness and bending of the clamp do not interfere with the proper engagement of the DMD and system connectors. The 1.0-mm mated height between the DMD and PCB (or FPCB) is shown in Figure 24.

## 5 System Connector

The connector on the DMD is an 80-contact 0.4-mm pitch, made by Panasonic. The mating connector is either a Panasonic AXT580124DD1 or AXT580124. These are equivalent connectors in all aspects. The mated height for the pair of connectors (distance between DMD and PCB) is 1.0 mm. Information about the mating connector is available on the Panasonic web site by searching on the part number AXT580124. Searching on the part number AXT580124DD1 will not yield any results.

## 6 Drawing and 3D-CAD File References

Drawings (in pdf format) and 3D-CAD models (in STEP format) for many of the parts discussed in this application are available to facilitate study, when designing an end-application. Two 3D-CAD files are available for the DMD. The first represents the nominal geometry of all the features and the second represents nominal geometry for all the features except the encapsulation, which is modeled at the maximum encapsulation size.Table 3 summarizes the literature numbers for the drawings and 3D-CAD models that are available for download.

**Table 3. Reference Drawings and 3D-CAD Models**

| FILE NAME | DESCRIPTION |
|---|---|
| DLPS028 | DLP4500FQE DMD (Series 241) Data Sheet |
| DLPC066 | DLP4500FQE DMD (Series 241) 3D-CAD model file with nominal geometry |
| DLPC067 | DLP4500FQE DMD (Series 241) 3D-CAD model file with maximum encapsulation geometry |
| DLPC068 | Assembly and Part drawing of Shim Alignment Mounting Concept (2513190) – also includes 3D-CAD model file |
| DLPC069 | Assembly and Part drawing of Clamp Alignment Mounting Concept (2511460) – also includes 3D-CAD model file |

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