DLP® Series-220 DMD and System Mounting Concepts

Application Report

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1 Scope

This application report serves as an aid to the successful utilization and implementation of the Series-220 DMD (DLP3000) and addresses the following topics:

- Terminology
- Specification and design details of a Series-220 DMD
- System mounting concepts for a Series-220 DMD, including key attributes and important application design considerations
- Connectors for use with a Series-220 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 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-220 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 substrate
- 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 bond wires
- System interface connector – the electrical interface between the Ceramic substrate and the end-application electronics
- Thermal interface area – the area on the ceramic substrate which allows direct contact of a heat sink or other thermal cooling device
- 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 which contains the DMD active array, window glass, and window aperture

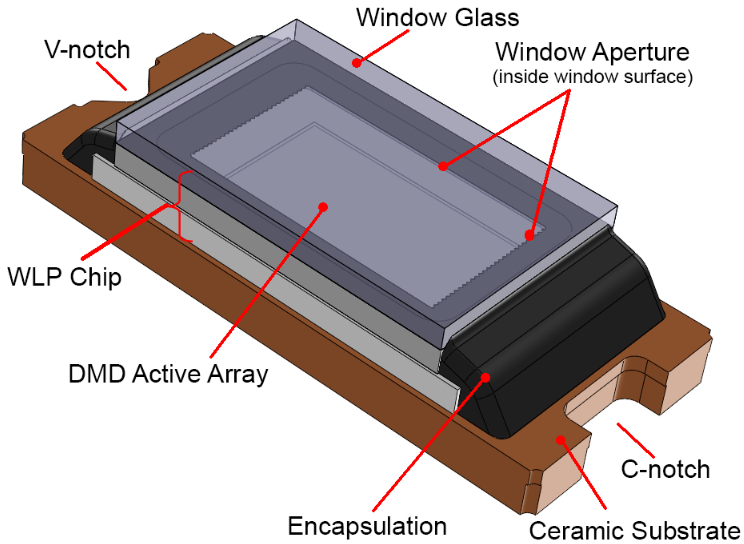

Figure 1. DMD Features – Window Side

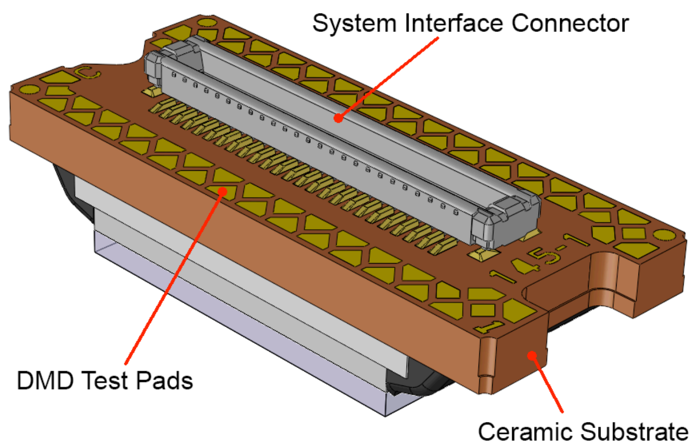

Figure 2. DMD Features – Connector Side

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 more specifically at the DMD active array and within the same plane as the active array

LGA – Land Grid Array (refers to a two-dimension 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 and Mechanical ICD. In case of any conflict between this document and either the data sheet or Mechanical ICD, use the data sheet and Mechanical ICD. (The Mechanical ICD is also referred to as the Package Mechanical Characteristics in the DMD data sheet.) A 3D-CAD file of the DMD nominal geometry in STEP format is available for download, see Section 6.

3.1 Documentation Structure

The technical information for the DMD is contained in two sections of the data sheet, the basic part of the Data Sheet and the Mechanical ICD.

The overall size, datum locations, tolerances, and other geometric information are in the DMD Mechanical ICD. The Mechanical ICD may be a separate document from the basic part of the data sheet, or incorporated into the data sheet.

The functional characteristics and usage environment are in the DMD data sheet (DLPS022A).

Table 1 summarizes the content of each document.

Table 1. DMD Data Sheet Information

DMD Technical Information	Data Sheet	Mech ICD
Package geometry (dimensions, mounting datums, window thickness, window aperture size, active array size, and so forth)		X
Thermal characteristics	X	
Mechanical mounting loads	X	
Optical properties (window material, mirror tilt angle, mirror size, and so forth)	X	
Electrical characteristics (signal names, voltage, wave form, and so forth)	X	
Operating environment	X	
Storage environment	X	
Part identification	X	

3.2 Optical Interface Features

To facilitate the physical orientation of the DMD active array relative to other optical components in the optical assembly the Series-220 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. 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. The specific size and location of the areas that define Datum ‘A’ are specified in the Mechanical ICD.
- 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. The location, size, and tolerance of the V-notch feature is defined in the Mechanical ICD.

- Datum ‘C’ – Tertiary datum
  - Datum ‘C’ is the center of a 3.0-mm wide C-shaped cutout on the edge of the ceramic substrate. 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. The location, size, and tolerance of the cutout are defined in the Mechanical ICD.

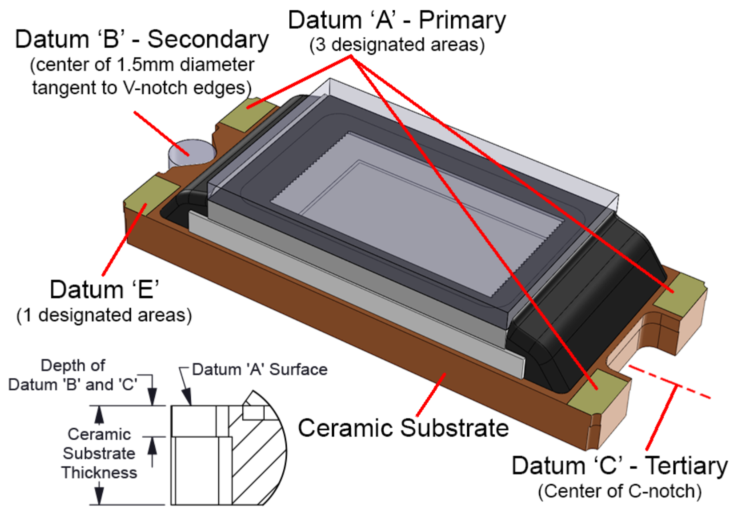

Figure 3. DMD Datum Features

3.3 DMD Cross Section Features

Figure 4 illustrates the features of the DMD in cross-section. 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 are illustrated. The nominal distance and tolerance between these features are defined in the DMD Mechanical ICD.

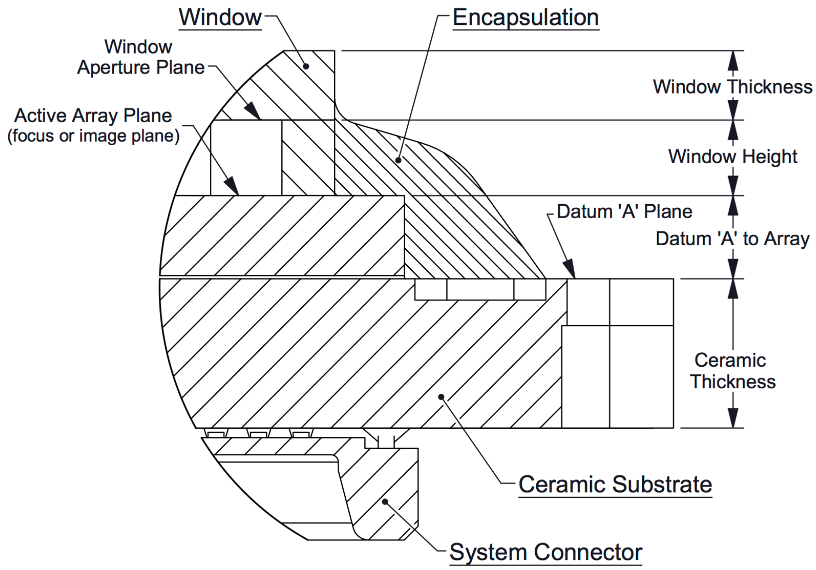

Figure 4. DMD Cross-Section View Features

3.4 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 not limited to) integrator size, illumination source, and optical aberrations (such as distortion, or color separation, or both).

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

The magnitude of these effects depends upon several factors that include (but 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 the 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.

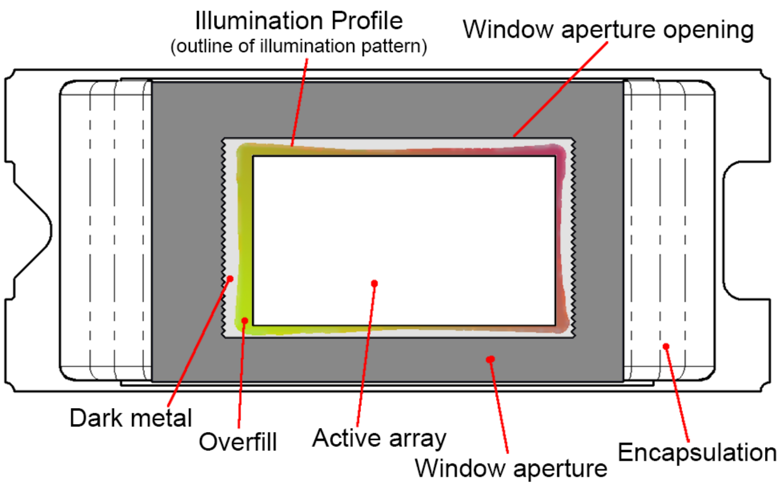

Figure 5. Optical Illumination Overfill

3.5 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 that dust particles on the outside window surface get reimaged and appear 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 fit, or optical focus uniformity issues.

3.6 Active Array Size and Location

The active array size and location is specified in the Mechanical ICD drawing. 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 (refer to the Mechanical ICD for specific dimensions).

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 (refer to the Mechanical ICD for specific dimensions). Note the center of the V-notch radius and center of Datum ‘B’ are not coincident, see Figure 7.

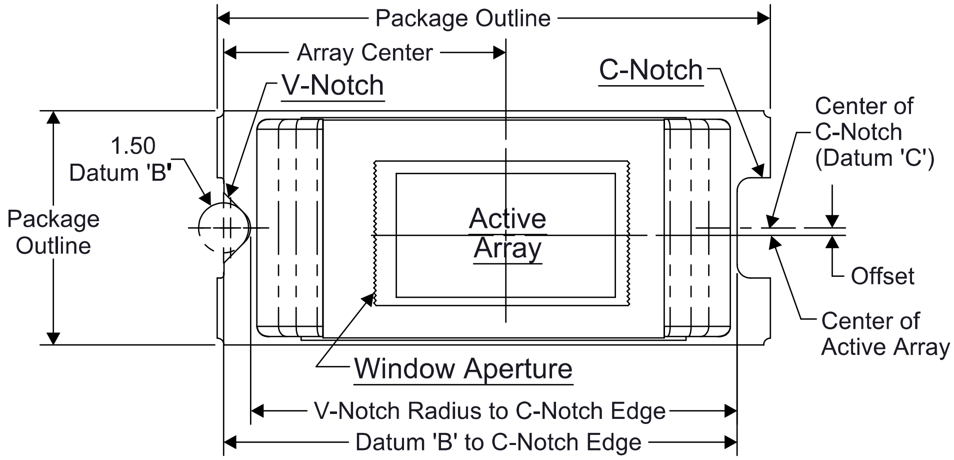

Figure 6. Active Array Location

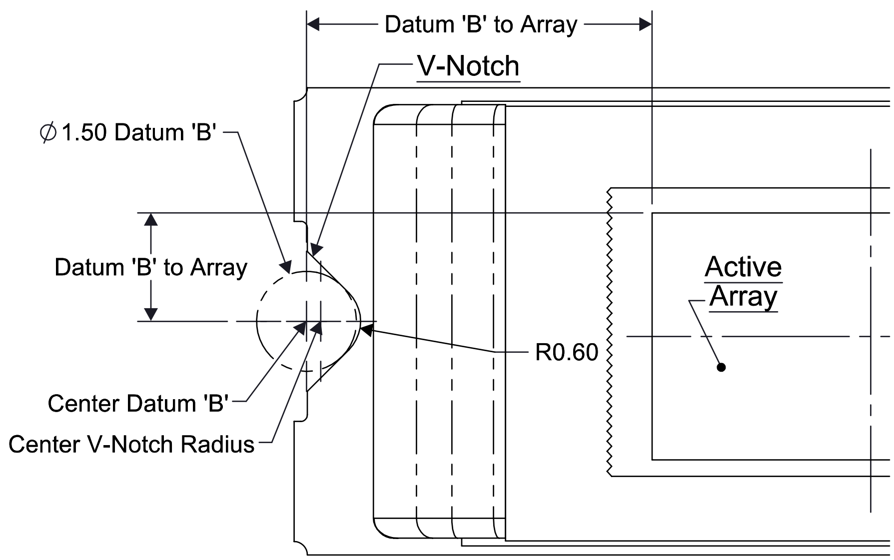

Figure 7. Active Array Location and V-notch Detail

3.7 Electrical Interface Features

The electrical interface to the Series-220 DMD is a BTB connector. The connector is a 50 contact 0.4-mm pitch with a Panasonic part number AXT650224DD1. The matting connector is either a Panasonic AXT550224DD1 or AXT550224. These are equivalent connectors in all aspects.

The pin numbering scheme for the BTB connector used on Series-220 DMDs is illustrated in Figure 8. The signal names for each pin D1–D25 and E1–E25 are identified in the DMD data sheet (DLPS022).

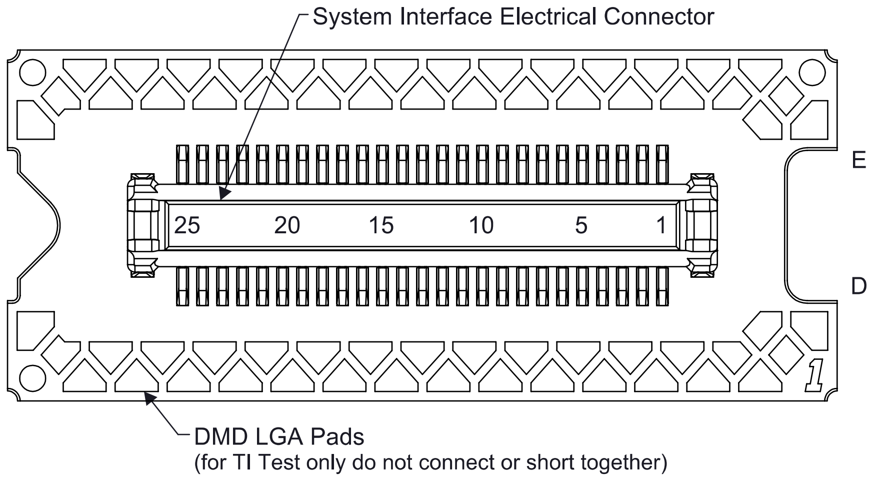

Figure 8. Pin Numbering Scheme

The LGA pads surrounding the BTB connector are used for TI 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.

3.8 Thermal Characteristics

The Series-220 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.

Two types of thermal specifications are provided in the DMD Data Sheet: Recommend Operating Conditions, and Absolute Maximum Ratings.

The Recommended Operating Conditions in the data sheet contain thermal specifications that represent the temperature limits within which the DMD will meet all operational specifications.

The Absolute Maximum Ratings in the data sheet contain temperature specifications that represent the temperature limits within which no permanent (physical) damage will occur to the DMD. Exposing the DMD to temperatures beyond the Absolute Maximum Ratings can cause irreversible damage, and should be avoided. The Absolute Maximum Ratings are provided as stress limits for use in accelerated reliability stress testing. Full-function operation of the DMD should not be expected when conditions exceed those specified in the Absolute Maximum Ratings. Operation of the DMD at the Absolute Maximum Ratings will generally result in shorter service life than one operated at the Recommended Operating Conditions.

The temperature specifications are for the specific test points identified in the data sheet and the active array. The active array temperature cannot be measured directly but must be computed analytically using information in the DMD data sheet, measurement of the thermal test point, and the thermal load absorbed from the illumination energy. The relationship to calculate the active array temperature from this information is shown in the DMD data sheet and described in Section 3.8.2.

The image that is displayed when making the temperature measurements should be the image that produces the worst-case temperatures. For an end-application where the largest thermal load is the illumination on the DMD (rather than the electrical load of the DMD) the worst-case temperatures would typically result from an all black image. For an end-application where the energy on the active array is low and the thermal load on the DMD is dominated by the electrical load, the worst-case temperatures would typically result from a “white noise” image.

3.8.1 Thermal Test Points

The Series 220 DMD has one defined thermal test point on the connector side of the ceramic. The minimum and maximum thermal requirements are summarized in Table 2, see the DMD data sheet (DLPS022) for the specific values of the DMD being used. The temperature of the reference locations can be measured directly, but the active array temperature must be computed as described in Section 3.8.2.

Table 2. Absolute Minimum and Maximum Temperatures

PARAMETERS		MIN	MAX	UNITS
Operating temperature	Test Point 3 in Figure 9 and Active Array	See data sheet DLPS022	See data sheet DLPS022	°C
Storage temperature (non-operating)	Test Point 3 in Figure 9	See data sheet DLPS022	See data sheet DLPS022	°C

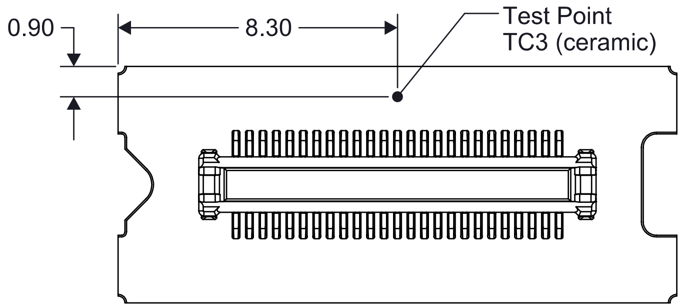

Figure 9. Thermal Test Points

3.8.2 Array Temperature and its Calculation

The total thermal load on the DMD is a result from the electrical power dissipated by the DMD, plus the optical energy absorbed by the DMD. The electrical load used for the active array calculations should be measured, when possible. If measurement is not possible a typical value (associated with a display application) is identified in the DMD data sheet. The energy absorbed from the illumination source is variable and depends on the operating state of the mirrors, the intensity of the light source, and the spatial distribution of overfill illumination. The energy absorbed from the optical load must be determined for each specific end-application and each specific illumination design.

The active array temperature can be calculated using the following formulas.

$$T_{Array} = T_{Ceramic} + (Q_{Array} \times R_{Array\text{-}To\text{-}Ceramic})$$

$$Q_{Array} = Q_{ELE} + Q_{ILL}$$

Where:

T_{Array} = computed active array temperature (°C)
$T_{Ceramic}$ = temperature measured at the Thermal Test Point on the connector side (°C)
Q_{Array} = total thermal load on the DMD active array (electrical + absorbed) (watts)
$R_{Array\text{-}To\text{-}Ceramic}$ = thermal resistance between the Thermal Test Point and the DMD active array (°C/watt) (specified in the DMD data sheet DLPS022)
Q_{ELE} = electrical power consumption (watts) (measured if possible, otherwise, refer to the DMD data sheet for a typical value)
Q_{ILL} = Absorbed optical energy (watts) (end-application specific)

The DMD thermal load can vary from unit-to-unit due to variations, and variations in the illumination source over time. Therefore, when verifying the thermal design of a specific end-application it is important to verify the amount of illumination energy each time a series of temperature measurements are taken.

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 using 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.**

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.

3.8.2.1 Sample Active Array Calculation for a 1-Chip Display Application

For a typical 1-chip display application the thermal load on the DMD from the illumination has been characterized to a factor based on average measured screen intensity. A conversion factor for energy on the DMD based on measured screen intensity (lumens) is 0.00274 times the measured screen lumens. This is based on the following:

- efficiency from DMD to the screen of 87%
- spectral efficiency of 300 lumens per watt of projected light
- illumination distribution on the DMD of
  - 83.7% on the active array
  - 16.3% on the dark metal border around the active array
  - 0.0% on the window aperture

An example of the active array temperature calculation for this display application using a 0.3 WVGA Series-220 DMD is shown below.

Measured data of:

SL = 150 lumens (measured)

$T_{Ceramic}$ = 55°C (measured)

$T_{Array} = T_{Ceramic} + (Q_{Array} \times R_{Array\text{-}To\text{-}Ceramic})$

$Q_{Array} = Q_{ELE} + Q_{ILL}$

$Q_{ILL} = 0.00274 \times SL$

Where:

T_{Array} = computed active array temperature (°C)
$T_{Ceramic}$ = temperature measured at Thermal Test Point TC3 (°C)
Q_{Array} = total thermal load on the DMD active array (electrical + absorbed) (watts)
$R_{Array\text{-}To\text{-}Ceramic}$ = thermal resistance between the Thermal Test Point (TC3) and the DMD active array is 5°C per watt) (from the DMD data sheet DLPS022)
Q_{ELE} = electrical power consumption is 0.105 watts (from the DMD data sheet)
SL = measured screen intensity (lumens)
Q_{ILL} = absorbed optical energy for this display application (watts)

Then:

$Q_{Array} = 0.105 + (0.00274 \times 150) = 0.52$ watts
$T_{Array} = 55°C + (0.52 \text{ watts} \times 5°C/\text{watt}) = 57.6°C$

3.8.3 Temperature and UV

In addition to specifying the Absolute Maximum and Recommended Operating temperature ranges, the DMD data sheet specifies the maximum UV power density that can be incident upon the active array, or overfill areas, or both. To ensure the longest possible reliability, the DMD should not be exposed to the maximum operating temperature and maximum UV levels at the same time.

3.9 Mechanical Loading

Installing a DMD into an end-application 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 10. The load is the maximum to be applied during the installation process, or the continuous load after the DMD has been installed.

- Connector area

The Series-220 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-220 DMD is designed to accommodate a mechanical load evenly distributed across the three areas shown in Figure 10. 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-220 DMD is designed to accommodate a mechanical load evenly distributed across the three Datum ‘A’ areas shown in Figure 10. The load functions to counteract the combined loads from the connector and mounting 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 10 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.

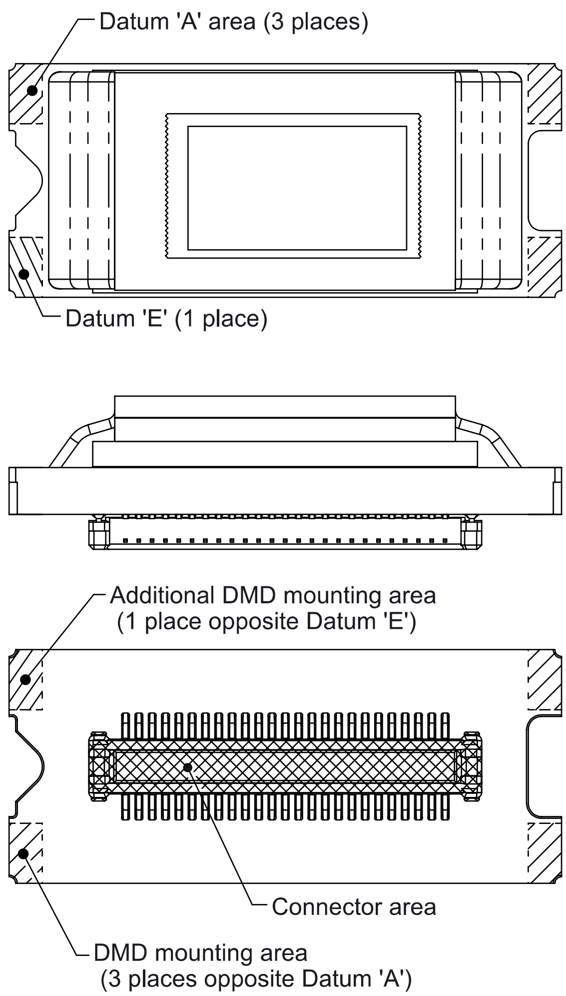

Figure 10. DMD Mechanical Loads

4 System DMD Mounting

4.1 Critical Considerations for Mounting and Utilizing 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 connection.

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 to 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 damage 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 times 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 DMD 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 DMD interchangeability 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 however 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 (defined in the DMD Mechanical ICD)

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 3.2 reviewed the Optical Interface Features of the DMD. This section reviews the suggested corresponding features on the optical chassis. The alignment features shown in Figure 11 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’ Ø1.5-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)
- Threaded bosses to mount a clamp, 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.

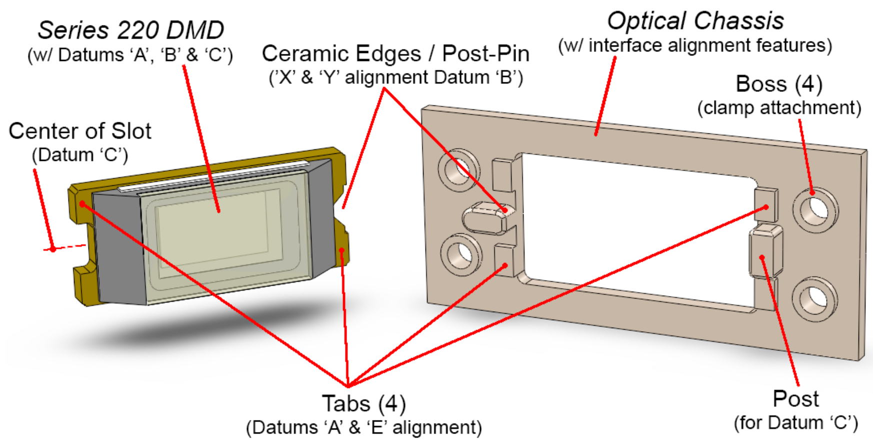

Figure 11. Optical Interface (Alignment) Features

The following characteristics of the Series-220 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 11.
- The three Datum ‘A’ tabs and the 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.
- 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.
- 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 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.
- The optical chassis features that contact DMD Datum ‘B’ and Datum ‘C’ should be lower in height than the ceramic thickness and associated tolerances. The lower height will prevent interference with the mating connector or mounting parts associated with holding the DMD in place. This clearance is illustrated in Figure 12.

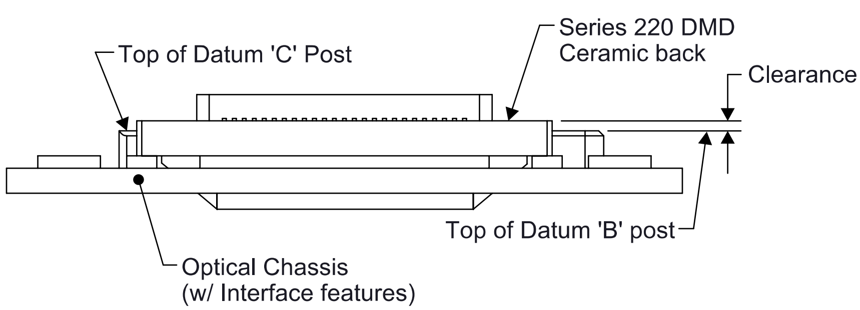

Figure 12. Mounting Clearance

- The DMD V-notch Datum ‘B’ is not a closed feature in the substrate. The intended use of Datum ‘B’ when mounting the DMD requires the DMD Datum ‘B’ contact the Datum ‘B’ post. 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.

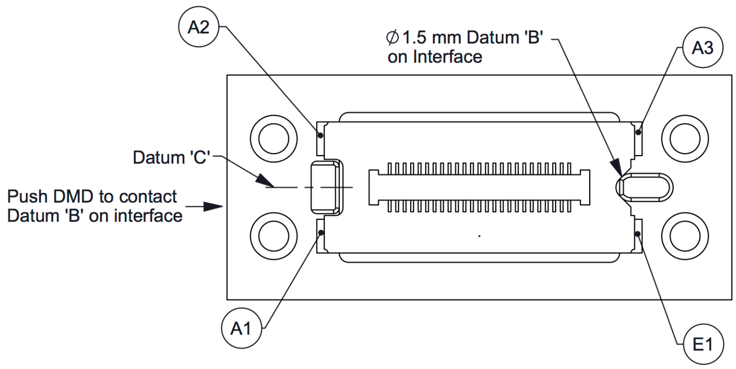

Figure 13. Mounting Datum 'B' Contact

4.2.2 Heat Sink

The Series-220 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.

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 Concepts

Detailed concepts for mounting the DMD that will meet the needs stated earlier are described in this section.

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, and other customer needs.

4.3.1 Clamp Mounting Concept

The design concept for mounting the Series-220 DMD shown in Figure 14 is a drop-in-place concept which incorporates specific features in the clamp to aid DMD alignment during the DMD installation process. Section 4.3.1.1 describes the details of the clamp features. The function of the clamp is to hold the DMD in place, and in so doing, applies mechanical loads to the DMD. Section 4.3.1.2 describes the control of the mechanical loads applied to the DMD.

The drawing number for the “Clamp Mounting Concept” shown in Figure 15 is 2510320. Drawings (PDF) and 3D-CAD models (in STEP format) of each part shown are available for download, see Reference Section 6.

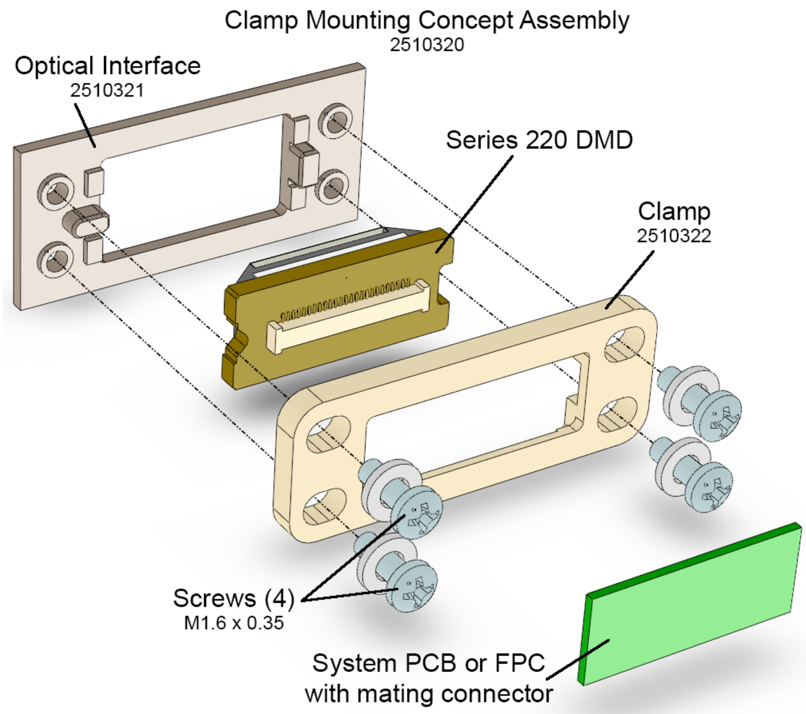

Figure 14. Clamp Mounting Concept

4.3.1.1 Clamp Features

The proper location of the active array requires the DMD be manually pushed into contact with the optical interface Datum ‘B’ post and held in place while the screws are tightened. The direction of the clamp movement is shown in Figure 15. This design includes clamp features to help facilitate this movement. Other clamp designs are possible, which could automatically push the DMD to contact the interface Datum ‘B’, but are not covered in this document.

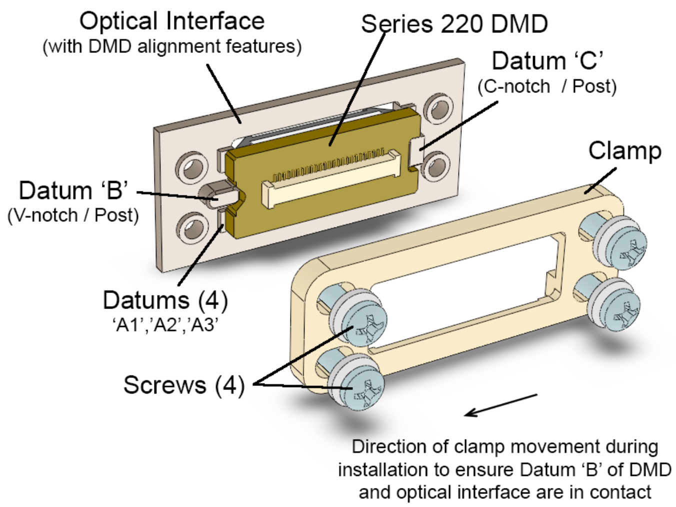

Figure 15. Clamp Movement

Figure 16 and Figure 17 illustrate the clamp features which contact the DMD on the short side opposite the V-notch and facilitate the movement of the clamp so the DMD contacts the interface Datum 'B'.

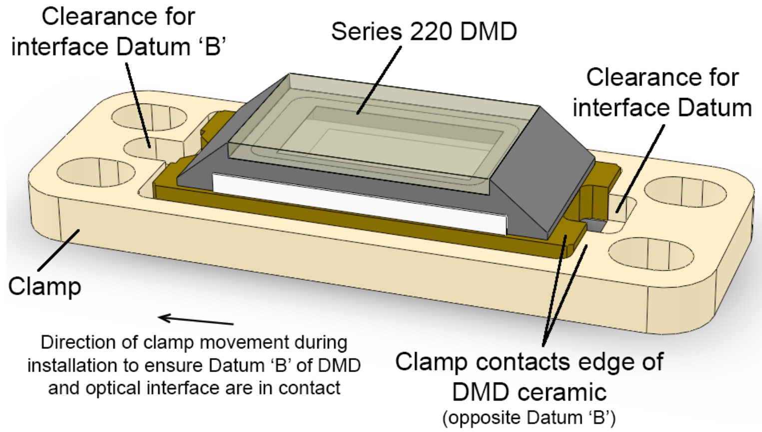

Figure 16. Clamp Contact on DMD Edge

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 17. 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.

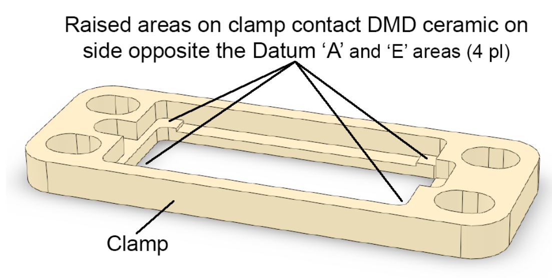

Figure 17. Clamp Datum 'A' and 'E' Contact

4.3.1.2 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 4 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 and is summarized here:

- Partially tighten all 4 screws prior to final tightening
- Control the torque on the screws
- Use alternating order when tightening the screws for both partial and final torque
- Tolerance 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 the Figure 18.

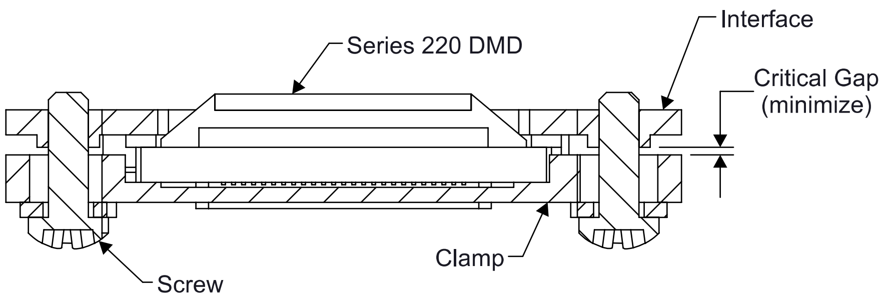

Figure 18. Critical Gap for Control of Load

The use of torque on the screws to control the forces applied to the DMD is highly dependent on the material variations and friction factors of the screws and optical interface material. Generally, the force on the DMD will vary widely because of these. The clamp will usually bow until the clamp contacts a feature on the optical chassis interface (threaded boss). Minimizing the gap between the threaded boss and clamp helps to reduce the chances of applying excess forces to the DMD, but does not guarantee it.

An analysis of the gap between the clamp and the interface (threaded boss) will identify the potential amount of bending that could occur. Figure 19 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 boss.

The minimum and maximum gap size for this design are shown in Table 3 for both a SUM and RSS tolerance analysis method. This shows the gap could be as small as 0.04 mm or as large as 0.56 mm for the SUM analysis method.

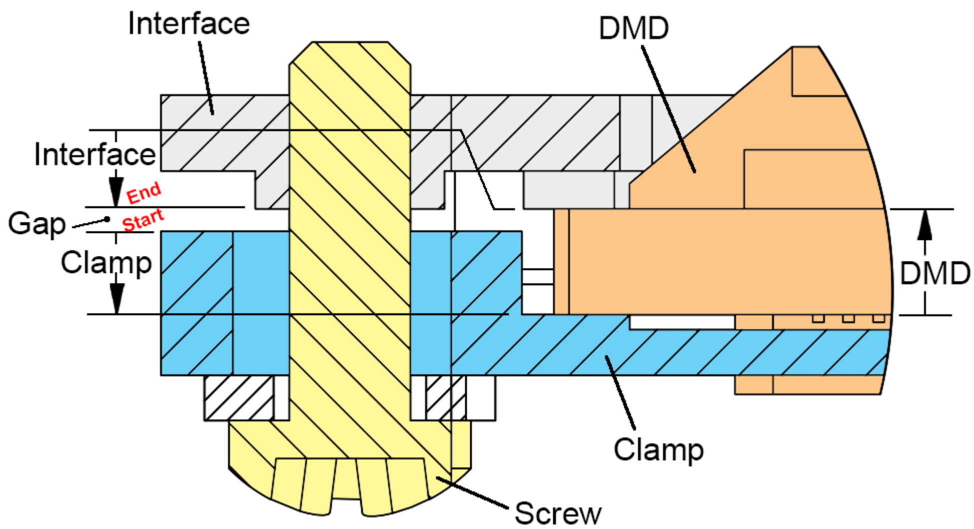

Figure 19. Tolerance Analysis Schematic

Table 3. Analysis of Gap Between Interface Boss and Clamp

	Nominal (mm)	Direction Sign	Nominal[(1)] (mm)	Tol (±) (mm)	Tolerance Method	GAP	
						MIN	MAX
Clamp	1.100	1	1.100	0.080			
DMD	1.400	–1	–1.400	0.100			
Interface	0.000	1	0.000	0.080			
	Sum		–0.300	0.260	**SUM**	0..040	0.560
				0.151	**RSS**	0.149	0.451

(1) Nominal value must be Negative to a gap between clamp and interface.

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 FPCB that connects to the DMD fit between the clamp mounting screws. The mated connector height for the connector pair is 1.2 mm. If the PCB or FPCB overhangs the mounting screws adjustments will need to be made to accommodate this.

5 System Connector

The connector on the DMD is a 50 contact 0.4-mm pitch made by Panasonic. The matting connector is either a Panasonic AXT550224DD1 or AXT550224. These are equivalent connectors in all aspects. The mated height for the pair of connectors (distance between DMD and PCB) is 1.2 mm. Information about the mating connector is available on the Panasonic web site by searching on the part number AXT550224. Searching on the part number AXT550224DD1 will not yield any results.

6 Reference

Drawings (PDF) 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 4 summarizes the literature numbers for the drawings and 3D-CAD models that are available for download.

Table 4. Reference Drawings and 3D-CAD Models

File Name	Description
DLPS022	DLP3000 DMD data sheet (Series 220)
DLPC073	DLP3000 DMD (Series 220) 3D-CAD file with nominal geometry
DLPC074	DLP3000 DMD (Series 220) 3D-CAD file with maximum encapsulation geometry
DLPC075	Assembly and Part drawings of Clamp Mounting Concept (2510320) – also includes 3D-CAD files

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