

DLP471TP .47 4K UHD DMD

1 Features

- 0.47-Inch diagonal micromirror array
 - 4K UHD (3840 × 2160) display resolution
 - 5.4- μm micromirror pitch
 - $\pm 17^\circ$ micromirror tilt (relative to flat surface)
 - Bottom illumination
- High-speed serial interface (HSSI) input data bus
- Supports 4K UHD at 60 Hz
- Supports 1080p up to 240 Hz
- LED operation supported by DLPC6540 display controller, DLPA3005 power management IC (PMIC) and LED driver

2 Applications

- [Mobile smart TV](#)
- [Mobile projector](#)
- [Digital signage](#)

3 Description

The DLP471TP digital micromirror device (DMD) is a digitally controlled micro-electro-mechanical system (MEMS) spatial light modulator (SLM) that enables bright 4K UHD display systems. The TI DLP® products 0.47" 4K UHD chipset is composed of the DMD, [DLPC6540](#) display controller, and [DLPA3005](#) PMIC and LED driver. The compact physical size of the chipset provides a complete system solution that enables small form factor 4K UHD displays.

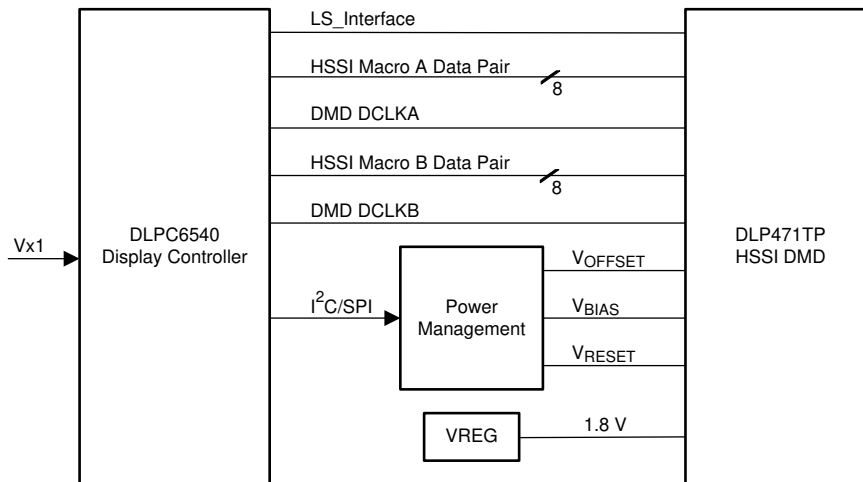
The DMD ecosystem includes established resources to help the user accelerate the design cycle, which include [production ready optical modules](#), [optical module manufacturers](#), and [design houses](#).

Visit the [Getting started with TI DLP® Pico™ display technology](#) page to learn more about how to start designing with the DMD.

Device Information (1)

| PART NUMBER | PACKAGE | BODY SIZE (NOM) |
|-------------|-----------|--------------------|
| DLP471TP | FQQ (270) | 25.65 mm × 16.9 mm |

(1) For all available packages, see the orderable addendum at the end of the data sheet.



Simplified Application



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4 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

| DATE | REVISION | NOTES |
|-------------|----------|------------------|
| August 2020 | * | Initial release. |

5 Pin Configuration and Functions

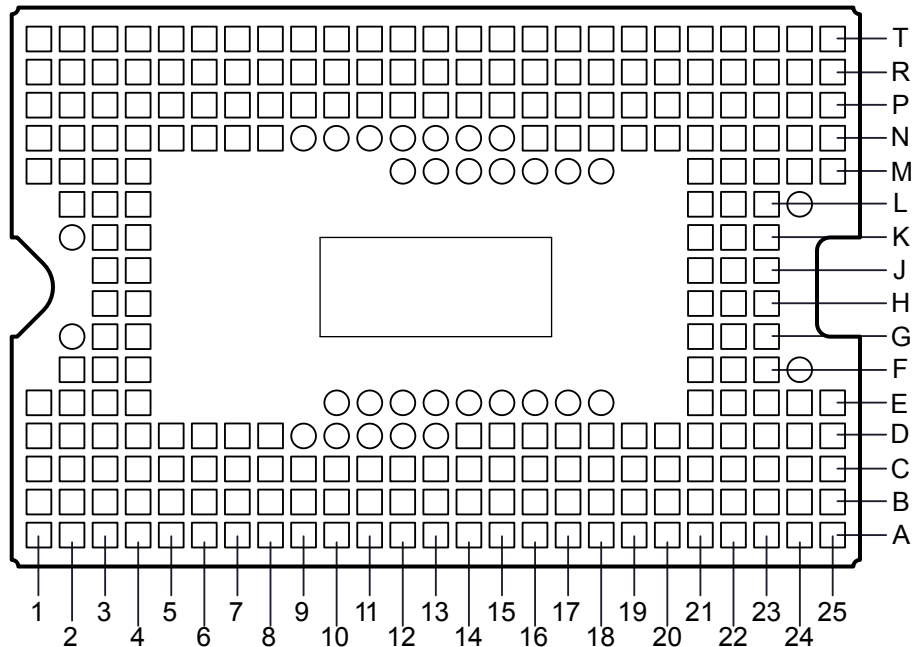


Figure 5-1. FQQ Package 270-Pin CLGA (Bottom View)

Table 5-1. Pin Functions

| PIN ⁽²⁾ | | INPUT- OUTPUT ⁽¹⁾ | DESCRIPTION | TERMINATION | TRACE LENGTH (mm) |
|--------------------|--------|---------------------------------|---|-------------------|-------------------------|
| NAME | PAD ID | | | | |
| D_AP(0) | A8 | I | High-speed Differential Data Pair lane A0 | Differential 100Ω | 2.15873 |
| D_AN(0) | A7 | I | High-speed Differential Data Pair lane A0 | Differential 100Ω | 2.16135 |
| D_AP(1) | B2 | I | High-speed Differential Data Pair lane A1 | Differential 100Ω | 8.33946 |
| D_AN(1) | C2 | I | High-speed Differential Data Pair lane A1 | Differential 100Ω | 8.34121 |
| D_AP(2) | A6 | I | High-speed Differential Data Pair lane A2 | Differential 100Ω | 6.41271 |
| D_AN(2) | A5 | I | High-speed Differential Data Pair lane A2 | Differential 100Ω | 6.41305 |
| D_AP(3) | A10 | I | High-speed Differential Data Pair lane A3 | Differential 100Ω | 1.8959 |
| D_AN(3) | A9 | I | High-speed Differential Data Pair lane A3 | Differential 100Ω | 1.8959 |
| D_AP(4) | D1 | I | High-speed Differential Data Pair lane A4 | Differential 100Ω | 12.11543 |
| D_AN(4) | E1 | I | High-speed Differential Data Pair lane A4 | Differential 100Ω | 12.11539 |
| D_AP(5) | D3 | I | High-speed Differential Data Pair lane A5 | Differential 100Ω | 12.01561 |
| D_AN(5) | E3 | I | High-speed Differential Data Pair lane A5 | Differential 100Ω | 12.0164 |
| D_AP(6) | F3 | I | High-speed Differential Data Pair lane A6 | Differential 100Ω | 12.98403 |
| D_AN(6) | G3 | I | High-speed Differential Data Pair lane A6 | Differential 100Ω | 12.98177 |
| D_AP(7) | A12 | I | High-speed Differential Data Pair lane A7 | Differential 100Ω | 2.29773 |
| D_AN(7) | A11 | I | High-speed Differential Data Pair lane A7 | Differential 100Ω | 2.29773 |
| DCLK_AP | A3 | I | High-speed Differential Clock A | Differential 100Ω | 11.75367 |
| DCLK_AN | A4 | I | High-speed Differential Clock A | Differential 100Ω | 11.57432 |
| D_BP(0) | A14 | I | High-speed Differential Data Pair lane B0 | Differential 100Ω | 2.10786 |
| D_BN(0) | A15 | I | High-speed Differential Data Pair lane B0 | Differential 100Ω | 2.10711 |
| D_BP(1) | F23 | I | High-speed Differential Data Pair lane B1 | Differential 100Ω | 12.79448 |

Table 5-1. Pin Functions (continued)

| PIN ⁽²⁾ | | INPUT- OUTPUT ⁽¹⁾ | DESCRIPTION | TERMINATION | TRACE LENGTH (mm) |
|--------------------|--------|---------------------------------|---|-------------------|-------------------------|
| NAME | PAD ID | | | | |
| D_BN(1) | G23 | I | High-speed Differential Data Pair lane B1 | Differential 100Ω | 12.79438 |
| D_BP(2) | E24 | I | High-speed Differential Data Pair lane B2 | Differential 100Ω | 13.00876 |
| D_BN(2) | E23 | I | High-speed Differential Data Pair lane B2 | Differential 100Ω | 13.00932 |
| D_BP(3) | A22 | I | High-speed Differential Data Pair lane B3 | Differential 100Ω | 11.21886 |
| D_BN(3) | A23 | I | High-speed Differential Data Pair lane B3 | Differential 100Ω | 11.21881 |
| D_BP(4) | D25 | I | High-speed Differential Data Pair lane B4 | Differential 100Ω | 10.79038 |
| D_BN(4) | D24 | I | High-speed Differential Data Pair lane B4 | Differential 100Ω | 10.78946 |
| D_BP(5) | A20 | I | High-speed Differential Data Pair lane B5 | Differential 100Ω | 5.75986 |
| D_BN(5) | A21 | I | High-speed Differential Data Pair lane B5 | Differential 100Ω | 5.75928 |
| D_BP(6) | B24 | I | High-speed Differential Data Pair lane B6 | Differential 100Ω | 9.01461 |
| D_BN(6) | B25 | I | High-speed Differential Data Pair lane B6 | Differential 100Ω | 9.01416 |
| D_BP(7) | A18 | I | High-speed Differential Data Pair lane B7 | Differential 100Ω | 2.08767 |
| D_BN(7) | A19 | I | High-speed Differential Data Pair lane B7 | Differential 100Ω | 2.08767 |
| DCLK_BP | A17 | I | High-speed Differential Clock B | Differential 100Ω | 2.12928 |
| DCLK_BN | A16 | I | High-speed Differential Clock B | Differential 100Ω | 2.30933 |
| LS_WDATA_P | T16 | I | LVDS Data | Differential 100Ω | 0 |
| LS_WDATA_N | R16 | I | LVDS Data | Differential 100Ω | 0.27407 |
| LS_CLK_P | T14 | I | LVDS CLK | Differential 100Ω | 2.43086 |
| LS_CLK_N | R14 | I | LVDS CLK | Differential 100Ω | 2.40852 |
| LS_RDATA_A_BISTA | R18 | O | LVC MOS Output | | 2.00263 |
| BIST_B | T20 | O | LVC MOS Output | | 4.61261 |
| AMUX_OUT | C21 | O | Analog Test Mux | | 3.03604 |
| DMUX_OUT | R20 | O | Digital Test Mux | | 2.88361 |
| DMD_DEN_ARSTZ | T18 | I | ARSTZ | 17.5kΩ pulldown | 1.89945 |
| TEMP_N | R12 | I | Temp Diode N | | 4.02546 |
| TEMP_P | T12 | I | Temp Diode P | | 3.62598 |

Table 5-1. Pin Functions (continued)

| PIN ⁽²⁾ | | INPUT- OUTPUT ⁽¹⁾ | DESCRIPTION | TERMINATION | TRACE LENGTH (mm) |
|--------------------|---|---------------------------------|--|-------------|-------------------------|
| NAME | PAD ID | | | | |
| VDD | B13, C5, C9, C12, C15, C18, C22, D6, D7, D14, D16, D19, D20, E21, G21, J4, J21, J23, K3, K22, L2, L4, L22, M1, M3, M21, M23, M25, N2, N4, N6, N8, N16, N18, N20, N22, N24, P3, P5, P7, P9, P11, P13, P15, P17, P19, P21, P23, P25, R2, R4, R6, R8, R10, T3, T5, T7, T9, T11, T13, T15, T17, T19, T21, T23 | P | Digital Core Supply Voltage | | Plane |
| VDDA | A24, B3, B5, B7, B9, B11, B14, B16, B18, B20, B22, C1, C24, D4, D23, E2, F4, F22, H3, H22 | P | HSSI Supply Voltage | | Plane |
| VRESET | A2, R1 | P | Supply Voltage for Negative Bias of Micromirror reset signal | | Plane |
| VBIAS | B1, P1 | P | Supply Voltage for Positive Bias of Micromirror reset signal | | Plane |
| VOFFSET | A1, A25, T1, T25 | P | Supply voltage for HVCMOS logic,stepped up logic level | | Plane |

Table 5-1. Pin Functions (continued)

| PIN ⁽²⁾ | | INPUT- OUTPUT ⁽¹⁾ | DESCRIPTION | TERMINATION | TRACE LENGTH (mm) |
|--------------------|--|---------------------------------|---------------|-------------|-------------------------|
| NAME | PAD ID | | | | |
| VSS | C4, C6, C8, C10, C13, C14, C17, C19, C23, D5, D8, D15, D17, D18, D21, D22, F21, H4, H21, J3, J22, K4, K21, K23, L3, L21, L23, M2, M4, M22, M24, N1, N3, N5, N7, N17, N19, N21, N23, N25, P2, P4, P6, P8, P10, P12, P14, P16, P18, P20, P22, P24, R3, R5, R7, R9, R11, R13, R15, R17, R19, R21, R23, R25, T2, T4, T8, T10 | G | Ground | | Plane |
| VSSA | A13, B4, B6, B8, B10, B12, B15, B17, B19, B21, B23, C3, C7, C11, C16, C20, C25, D2, E4, E22, E25, F2, G4, G22, H23 | G | Ground | | Plane |
| DMD_Detect | T6 | NC | DMD Detection | | None |

Table 5-1. Pin Functions (continued)

| PIN ⁽²⁾ | | INPUT- OUTPUT ⁽¹⁾ | DESCRIPTION | TERMINATION | TRACE LENGTH (mm) |
|--------------------|--|---------------------------------|----------------|-------------|-------------------------|
| NAME | PAD ID | | | | |
| N/C | D9, D10, D11, D12, D13, E10, E11, E12, E13, E14, E15, E16, E17, E18, F24, G2, K2, L24, M12, M13, M14, M15, M16, M17, M18, N9, N10, N11, N12, N13, N14, N15, R22, R24 ,T22, T24 | NC | No Connect Pin | | None |

(1) I=Input, O=Output, P=Power, G=Ground, NC = No Connect

(2) Only 238 pins are electrically connected for functional use.

6 Specifications

6.1 Absolute Maximum Ratings

Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only, and functional operation of the device is not implied at these or any other conditions beyond those indicated under Recommended Operating Conditions. Exposure above or below the Recommended Operating Conditions for extended periods may affect device reliability.

| | | MIN | MAX | UNIT |
|---|---|------|-----------|------|
| SUPPLY VOLTAGE | | | | |
| V_{DD} | Supply voltage for LVCMOS core logic and LVCMOS low speed interface (LSIF) ⁽¹⁾ | -0.5 | 2.3 | V |
| V_{DDA} | Supply voltage for high speed serial interface (HSSI) receivers ⁽¹⁾ | -0.3 | 2.2 | V |
| V_{OFFSET} | Supply voltage for HVCMOS and micromirror electrode ^{(1) (2)} | -0.5 | 11 | V |
| V_{BIAS} | Supply voltage for micromirror electrode ⁽¹⁾ | -0.5 | 19 | V |
| V_{RESET} | Supply voltage for micromirror electrode ⁽¹⁾ | -15 | 0.5 | V |
| $ V_{DDA} - V_{DD} $ | Supply voltage delta (absolute value) ⁽³⁾ | | 0.3 | V |
| $ V_{BIAS} - V_{OFFSET} $ | Supply voltage delta (absolute value) ⁽⁴⁾ | | 11 | V |
| $ V_{BIAS} - V_{RESET} $ | Supply voltage delta (absolute value) ⁽⁵⁾ | | 34 | V |
| INPUT VOLTAGE | | | | |
| | Input voltage for other inputs – LSIF and LVCMOS ⁽¹⁾ | -0.5 | 2.45 | V |
| | Input voltage for other inputs – HSSI ^{(1) (6)} | -0.2 | V_{DDA} | V |
| LOW SPEED INTERFACE (LSIF) | | | | |
| f_{CLOCK} | LSIF clock frequency (LS_CLK) | | 130 | MHz |
| $ V_{ID} $ | LSIF differential input voltage magnitude ⁽⁶⁾ | | 810 | mV |
| I_{ID} | LSIF differential input current | | 10 | mA |
| HIGH SPEED SERIAL INTERFACE (HSSI) | | | | |
| f_{CLOCK} | HSSI clock frequency (DCLK) | | 1.65 | GHz |
| $ V_{ID} $ | HSSI differential input voltage magnitude Data Lane ⁽⁶⁾ | | 700 | mV |
| $ V_{ID} $ | HSSI differential input voltage magnitude Clock Lane ⁽⁶⁾ | | 700 | mV |
| ENVIRONMENTAL | | | | |
| T_{WINDOW} and T_{ARRAY} | Temperature, operating ⁽⁷⁾ | 0 | 90 | °C |
| | Temperature, non-operating ⁽⁷⁾ | -40 | 90 | °C |
| $ T_{DELTA} $ | Absolute temperature delta between any point on the window edge and the ceramic test point TP1 ⁽⁸⁾ | | 30 | °C |
| T_{DP} | Dew point temperature, operating and non-operating (noncondensing) | | 81 | °C |

- (1) All voltage values are with respect to the ground terminals (V_{SS}). The following required power supplies must be connected for proper DMD operation: V_{DD} , V_{DDA} , V_{OFFSET} , V_{BIAS} , and V_{RESET} . All V_{SS} connections are also required.
- (2) V_{OFFSET} supply transients must fall within specified voltages.
- (3) Exceeding the recommended allowable absolute voltage difference between V_{DDA} and V_{DD} may result in excessive current draw.
- (4) Exceeding the recommended allowable absolute voltage difference between V_{BIAS} and V_{OFFSET} may result in excessive current draw.
- (5) Exceeding the recommended allowable absolute voltage difference between V_{BIAS} and V_{RESET} may result in excessive current draw.
- (6) This maximum input voltage rating applies when each input of a differential pair is at the same voltage potential. LVDS and HSSI differential inputs must not exceed the specified limit or damage may result to the internal termination resistors.
- (7) The highest temperature of the active array (as calculated using [Micromirror Array Temperature Calculation](#)) or of any point along the window edge as defined in [Figure 7-1](#). The locations of thermal test points TP2, TP3, TP4 and TP5 in [Figure 7-1](#) are intended to measure the highest window edge temperature. If a particular application causes another point on the window edge to be at a higher temperature, that point should be used.
- (8) Temperature delta is the highest difference between the ceramic test point 1 (TP1) and anywhere on the window edge as shown in [Figure 7-1](#). The window test points TP2, TP3, TP4, and TP5 shown in [Figure 7-1](#) are intended to result in the worst case delta. If a particular application causes another point on the window edge to result in a larger delta temperature, that point should be used.

6.2 Storage Conditions

Applicable for the DMD as a component or non-operating in a system.

| | | MIN | MAX | UNIT |
|--------------|---|-----|-----|--------|
| T_{DMD} | DMD temperature | -40 | 85 | °C |
| T_{DP-AVG} | Average dew point temperature, non-condensing ⁽¹⁾ | | 24 | °C |
| T_{DP-ELR} | Elevated dew point temperature range, non-condensing ⁽²⁾ | 28 | 36 | °C |
| CT_{ELR} | Cumulative time in elevated dew point temperature range | | 6 | months |

- (1) The average temperature over time (including storage and operating temperatures) that the device is not in the elevated dew point temperature range.
- (2) Exposure to dew point temperatures in the elevated range during storage and operation should be limited to less than a total cumulative time of CT_{ELR} .

6.3 ESD Ratings

| | | | VALUE | UNIT |
|-------------|-------------------------|--|-------|------|
| $V_{(ESD)}$ | Electrostatic discharge | Human body model (HBM), per ANSI/ESDA/JEDEC JS-001 ⁽¹⁾ | ±2000 | V |
| | | Charged device model (CDM), per JEDEC specification JESD22-C101 ⁽²⁾ | ±500 | V |

- (1) JEDEC document JEP155 states that 500 V HBM allows safe manufacturing with a standard ESD control process.
- (2) JEDEC document JEP157 states that 250 V CDM allows safe manufacturing with a standard ESD control process.

6.4 Recommended Operating Conditions

Over operating free-air temperature range and supply voltages (unless otherwise noted). The functional performance of the device specified in this data sheet is achieved when operating the device within the limits defined by the [Recommended Operating Conditions](#). No level of performance is implied when operating the device above or below the [Recommended Operating Conditions](#) limits.

| | | MIN | TYP | MAX | UNIT |
|---|---|----------------|-----|-------|------|
| SUPPLY VOLTAGES ^{(1) (2)} | | | | | |
| V_{DD} | Supply voltage for LVCMOS core logic and low speed interface (LSIF) | 1.71 | 1.8 | 1.95 | V |
| V_{DDA} | Supply voltage for high speed serial interface (HSSI) receivers | 1.71 | 1.8 | 1.95 | V |
| V_{OFFSET} | Supply voltage for HVCMOS and micromirror electrode ⁽³⁾ | 9.5 | 10 | 10.5 | V |
| V_{BIAS} | Supply voltage for micromirror electrode | 17.5 | 18 | 18.5 | V |
| V_{RESET} | Supply voltage for micromirror electrode | -14.5 | -14 | -13.5 | V |
| $ V_{DDA} - V_{DD} $ | Supply voltage delta, absolute value ⁽⁴⁾ | | | 0.3 | V |
| $ V_{BIAS} - V_{OFFSET} $ | Supply voltage delta, absolute value ⁽⁵⁾ | | | 10.5 | V |
| $ V_{BIAS} - V_{RESET} $ | Supply voltage delta, absolute value | | | 33 | V |
| LVCMOS INPUT | | | | | |
| V_{IH} | High level input voltage ⁽⁶⁾ | 0.7 x V_{DD} | | | V |
| V_{IL} | Low level input voltage ⁽⁶⁾ | 0.3 x V_{DD} | | | V |
| LOW SPEED SERIAL INTERFACE (LSIF) | | | | | |
| f_{CLOCK} | LSIF clock frequency (LS_CLK) ⁽⁷⁾ | 108 | 120 | 130 | MHz |
| DCD_{IN} | LSIF duty cycle distortion (LS_CLK) | 44 | | 56 | % |
| $ V_{ID} $ | LSIF differential input voltage magnitude ⁽⁷⁾ | 150 | 350 | 440 | mV |
| V_{LVDS} | LSIF voltage ⁽⁷⁾ | 575 | | 1520 | mV |
| V_{CM} | Common mode voltage ⁽⁷⁾ | 700 | 900 | 1300 | mV |
| Z_{LINE} | Line differential impedance (PWB/trace) | 90 | 100 | 110 | Ω |
| Z_{IN} | Internal differential termination resistance | 80 | 100 | 120 | Ω |
| HIGH SPEED SERIAL INTERFACE (HSSI) | | | | | |
| f_{CLOCK} | HSSI clock frequency (DCLK) ⁽⁸⁾ | 1.2 | | 1.6 | GHz |

Over operating free-air temperature range and supply voltages (unless otherwise noted). The functional performance of the device specified in this data sheet is achieved when operating the device within the limits defined by the [Recommended Operating Conditions](#). No level of performance is implied when operating the device above or below the [Recommended Operating Conditions](#) limits.

| | | MIN | TYP | MAX | UNIT |
|------------------------|--|-----|------|--------------------------|--------------------|
| DCD _{IN} | HSSI duty cycle distortion (DCLK) | 44 | 50 | 56 | % |
| V _{ID} Data | HSSI differential input voltage magnitude Data Lane ⁽⁸⁾ | 100 | 400 | 600 | mV |
| V _{ID} CLK | HSSI differential input voltage magnitude Clock Lane ⁽⁸⁾ | 300 | 400 | 600 | mV |
| VCM _{DC} Data | Input common mode voltage (DC) Data Lane ⁽⁸⁾ | 200 | 600 | 800 | mV |
| VCM _{DC} CLK | Input common mode voltage (DC) Clk Lane ⁽⁸⁾ | 200 | 600 | 800 | mV |
| VCM _{ACP-P} | AC peak to peak (ripple) on common mode voltage of Data Lane and Clock Lane ⁽⁸⁾ | | | 100 | mV |
| Z _{LINE} | Line differential impedance (PWB/trace) | | 100 | | Ω |
| Z _{IN} | Internal differential termination resistance. (R _{xterm}) | 80 | 100 | 120 | Ω |
| ENVIRONMENTAL | | | | | |
| T _{ARRAY} | Array temperature, long-term operational ^{(9) (10) (11) (12)} | 10 | | 40 to 70 ⁽¹¹⁾ | °C |
| | Array temperature, short-term operational, 500 hr max ^{(10) (13)} | 0 | | 10 | °C |
| T _{WINDOW} | Window temperature, operational ⁽¹⁴⁾ | | | 85 | °C |
| T _{DELTA} | Absolute temperature delta between any point on the window edge and the ceramic test point TP1 ⁽¹⁵⁾ | | | 14 | °C |
| T _{DP-AVG} | Average dew point temperature (non-condensing) ⁽¹⁶⁾ | | | 24 | °C |
| T _{DP-ELR} | Elevated dew point temperature range (non-condensing) ⁽¹⁷⁾ | 28 | | 36 | °C |
| CT _{ELR} | Cumulative time in elevated dew point temperature range | | | 6 | months |
| ILL _{UV} | Illumination wavelength < 420 nm ⁽⁹⁾ | | 0.68 | 2 | mW/cm ² |
| ILL _{VIS} | Illumination wavelengths between 420 nm and 700 nm | | | Thermally limited | |
| ILL _{IR} | Illumination wavelength > 700 nm | | | 10 | mW/cm ² |
| ILL _θ | Illumination marginal ray angle ⁽¹⁸⁾ | | | 55 | degrees |

- (1) All power supply connections are required to operate the DMD: V_{DD}, V_{DDA}, V_{OFFSET}, V_{BIAS}, and V_{RESET}. All V_{SS} connections are required to operate the DMD.
- (2) All voltage values are with respect to the V_{SS} ground pins.
- (3) V_{OFFSET} supply transients must fall within specified max voltages.
- (4) To prevent excess current, the supply voltage delta |V_{DDA} – V_{DD}| must be less than specified limit.
- (5) To prevent excess current, the supply voltage delta |V_{BIAS} – V_{OFFSET}| must be less than specified limit.
- (6) LVCMOS input pin is DMD_DEN_ARSTZ.
- (7) See the low speed interface (LSIF) timing requirements in [Timing Requirements](#).
- (8) See the high speed serial interface (HSSI) timing requirements in [Timing Requirements](#).
- (9) Simultaneous exposure of the DMD to the maximum [Recommended Operating Conditions](#) for temperature and UV illumination reduces device lifetime.
- (10) The array temperature cannot be measured directly and must be computed analytically from the temperature measured at test point (TP1) shown in [Figure 7-1](#) and the package thermal resistance using the [Micromirror Array Temperature Calculation](#).
- (11) Per [Figure 6-1](#), the maximum operational array temperature should be derated based on the micromirror landed duty cycle that the DMD experiences in the end application. Refer to [Micromirror Landed-On/Landed-Off Duty Cycle](#) for a definition of micromirror landed duty cycle.
- (12) Long-term is defined as the usable life of the device.
- (13) Short-term is the total cumulative time over the useful life of the device.
- (14) The locations of thermal test points TP2, TP3, TP4, and TP5 shown in [Figure 7-1](#) are intended to measure the highest window edge temperature. For most applications, the locations shown are representative of the highest window edge temperature. If a particular application causes additional points on the window edge to be at a higher temperature, test points should be added to those locations.
- (15) Temperature delta is the highest difference between the ceramic test point 1 (TP1) and anywhere on the window edge as shown in [Figure 7-1](#). The window test points TP2, TP3, TP4, and TP5 shown in [Figure 7-1](#) are intended to result in the worst case delta temperature. If a particular application causes another point on the window edge to result in a larger delta in temperature, that point should be used.
- (16) The average over time (including storage and operating) that the device is not in the 'elevated dew point temperature range'.
- (17) Exposure to dew point temperatures in the elevated range during storage and operation should be limited to less than a total

cumulative time of CT_{ELR} .

- (18) The maximum marginal ray angle of the incoming illumination light at any point in the micromirror array, including pond of micromirrors (POM), should not exceed 55 degrees from the normal to the device array plane. The device window aperture has not necessarily been designed to allow incoming light at higher maximum angles to pass to the micromirrors, and the device performance has not been tested nor qualified at angles exceeding this. Illumination light exceeding this angle outside the micromirror array (including POM) will contribute to thermal limitations described in this document, and may negatively affect lifetime.

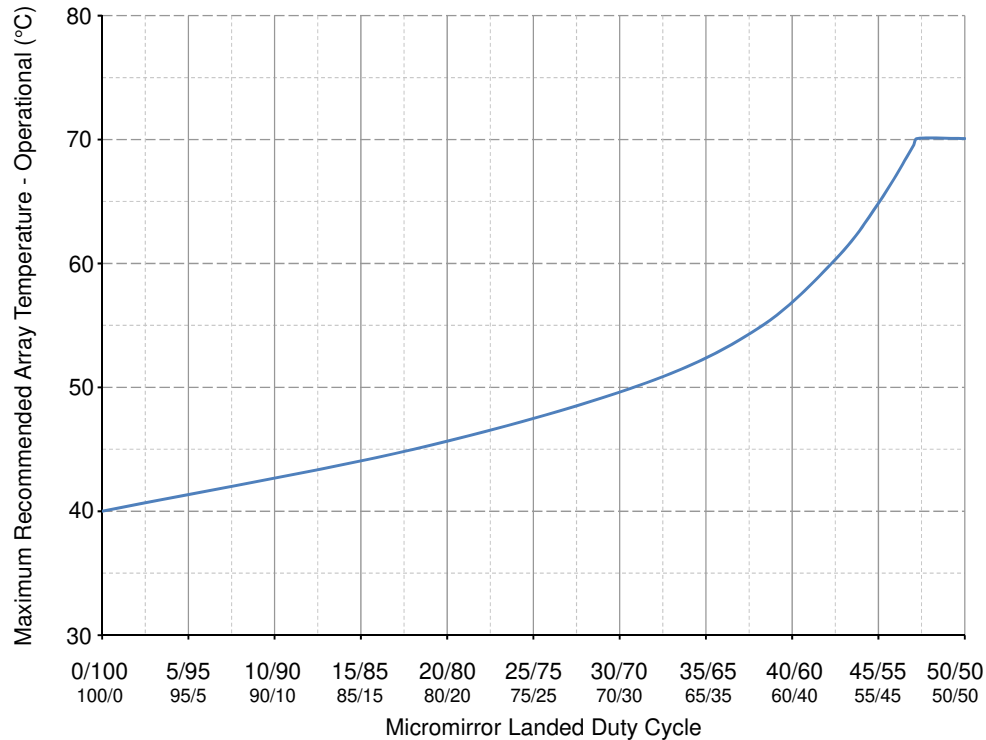


Figure 6-1. Maximum Recommended Array Temperature - Derating Curve

6.5 Thermal Information

| THERMAL METRIC | DLP471TP | Unit |
|--|-------------|------|
| | FQQ PACKAGE | |
| | 270 PIN | |
| Thermal Resistance, active area to test point 1 (TP1) ⁽¹⁾ | 1.0 | °C/W |

- (1) The DMD is designed to conduct absorbed and dissipated heat to the back of the package. The cooling system must be capable of maintaining the package within the temperature range specified in the [Section 6.4](#). The total heat load on the DMD is largely driven by the incident light absorbed by the active area; although other contributions include light energy absorbed by the window aperture and electrical power dissipation of the array. Optical systems should be designed to minimize the light energy falling outside the window clear aperture since any additional thermal load in this area can significantly degrade the reliability of the device.

6.6 Electrical Characteristics

Over operating free-air temperature range and supply voltages (unless otherwise noted)

| PARAMETER ⁽¹⁾ ⁽²⁾ | | TEST CONDITIONS ⁽¹⁾ | MIN | TYP | MAX | UNIT |
|---|---|--------------------------------|------|------|------|------|
| CURRENT – TYPICAL | | | | | | |
| I_{DD} | Supply current V_{DD} ⁽³⁾ | | | 800 | 1200 | mA |
| I_{DDA} | Supply current V_{DDA} ⁽³⁾ | | | 1000 | 1200 | mA |
| I_{OFFSET} | Supply current V_{OFFSET} ⁽⁴⁾ ⁽⁵⁾ | | | 20 | 25 | mA |
| I_{BIAS} | Supply current V_{BIAS} ⁽⁴⁾ ⁽⁵⁾ | | | 2.5 | 4.0 | mA |
| I_{RESET} | Supply current V_{RESET} ⁽⁵⁾ | | -9.3 | -6.9 | | mA |

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Over operating free-air temperature range and supply voltages (unless otherwise noted)

| PARAMETER ⁽¹⁾ ⁽²⁾ | | TEST CONDITIONS ⁽¹⁾ | MIN | TYP | MAX | UNIT |
|---|--|---|-----------------------|-------|-----------------------|------|
| POWER – TYPICAL | | | | | | |
| P _{DD} | Supply power dissipation V _{DD} ⁽³⁾ | | | 1440 | 2437.5 | mW |
| P _{D_{DA}} | Supply power dissipation V _{D_{DA}} ⁽³⁾ | | | 1620 | 2340 | mW |
| P _{OFFSET} | Supply power dissipation V _{OFFSET} ⁽⁴⁾ ⁽⁵⁾ | | | 230 | 367.5 | mW |
| P _{BIAS} | Supply power dissipation V _{BIAS} ⁽⁴⁾ ⁽⁵⁾ | | | 43.2 | 70.3 | mW |
| P _{RESET} | Supply power dissipation V _{RESET} ⁽⁵⁾ | | | 107.8 | 152.25 | mW |
| P _{TOTAL} | Supply power dissipation Total | | | 3441 | 5367.55 | mW |
| LVC MOS INPUT | | | | | | |
| I _{IL} | Low level input current ⁽⁶⁾ | V _{DD} = 1.95 V, V _I = 0 V | -100 | | | nA |
| I _{IH} | High level input current ⁽⁶⁾ | V _{DD} = 1.95 V, V _I = 1.95 V | | | 135 | uA |
| LVC MOS OUTPUT | | | | | | |
| V _{OH} | DC output high voltage ⁽⁷⁾ | I _{OH} = -2 mA | 0.8 x V _{DD} | | | V |
| V _{OL} | DC output low voltage ⁽⁷⁾ | I _{OL} = 2 mA | | | 0.2 x V _{DD} | V |
| RECEIVER EYE CHARACTERISTICS | | | | | | |
| A1 | Minimum data eye opening ⁽⁸⁾ ⁽⁹⁾ | | 100 | 400 | 600 | mV |
| A2 | Maximum data signal swing ⁽⁸⁾ ⁽⁹⁾ | | | | 600 | mV |
| X1 | Maximum data eye closure ⁽⁸⁾ | | | | 0.275 | UI |
| X2 | Maximum data eye closure ⁽⁸⁾ | | | | 0.4 | UI |
| t _{DRIFT} | Drift between Clock and Data between Training Patterns | | | | 20 | ps |
| CAPACITANCE | | | | | | |
| C _{IN} | Input capacitance LVC MOS | f = 1 MHz | | | 10 | pF |
| C _{IN} | Input capacitance LSIF (low speed interface) | f = 1 MHz | | | 20 | pF |
| C _{IN} | Input capacitance HSSI (high speed serial interface) | f = 1 MHz | | | 20 | pF |
| C _{OUT} | Output capacitance | f = 1 MHz | | | 10 | pF |

- (1) All power supply connections are required to operate the DMD: V_{DD}, V_{D_{DA}}, V_{OFFSET}, V_{BIAS}, and V_{RESET}. All V_{SS} connections are required to operate the DMD.
- (2) All voltage values are with respect to the ground pins (V_{SS}).
- (3) To prevent excess current, the supply voltage delta | V_{D_{DA}} – V_{DD} | must be less than specified limit.
- (4) To prevent excess current, the supply voltage delta | V_{BIAS} – V_{OFFSET} | must be less than specified limit.
- (5) Supply power dissipation based on 3 global resets in 200 μs.
- (6) LVC MOS input specifications are for pin DMD_DEN_ARSTZ.
- (7) LVC MOS output specification is for pins LS_RDATA_A and LS_RDATA_B.
- (8) Refer to [Figure 6-11](#), Receiver Eye Mask (1e-12 BER).
- (9) Defined in [Recommended Operating Conditions](#).

6.7 Switching Characteristics

Over operating free-air temperature range and supply voltages (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|-----------|---|---|-----|-----|------|------|
| t_{pd} | Output propagation, Clock to Q (C2Q), rising edge of LS_CLK (differential clock signal) input to LS_RDATA output. (1) | $C_L = 5 \text{ pF}$ | | | 11.1 | ns |
| | | $C_L = 10 \text{ pF}$ | | | 11.3 | ns |
| | Slew rate, LS_RDATA | 20%-80%, $C_L < 10 \text{ pF}$ | 0.5 | | | V/ns |
| | Output duty cycle distortion, LS_RDATA_A and LS_RDATA_B | 50-(C2Q rise - C2Q fall) * 130e6 * 100 | 40 | | 60 | % |

(1) See [Figure 6-2](#).

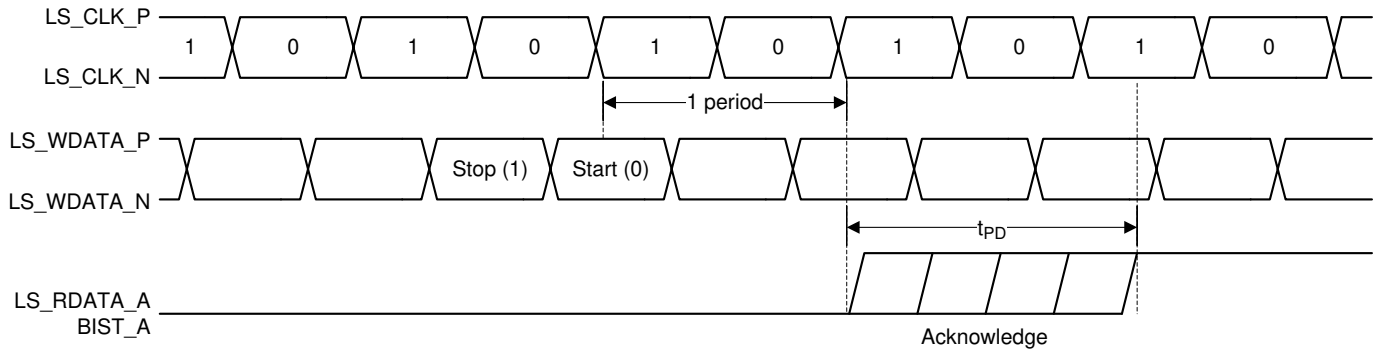


Figure 6-2. Switching Characteristics

6.8 Timing Requirements

Over operating free-air temperature range and supply voltages (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|------------------------------------|--|-------|-----|------|------|
| LVC MOS | | | | | | |
| t_r | Rise time ⁽¹⁾ | 20% to 80% reference points | | | 0.25 | ns |
| t_f | Fall time ⁽¹⁾ | 80% to 20% reference points | | | 0.25 | ns |
| LOW SPEED INTERFACE (LSIF) | | | | | | |
| t_r | Rise time ⁽²⁾ | 20% to 80% reference points | | | 450 | ps |
| t_f | Fall time ⁽²⁾ | 80% to 20% reference points | | | 450 | ps |
| $t_{W(H)}$ | Pulse duration high ⁽³⁾ | LS_CLK. 50% to 50% reference points | 3.1 | | | ns |
| $t_{W(L)}$ | Pulse duration low ⁽³⁾ | LS_CLK. 50% to 50% reference points | 3.1 | | | ns |
| t_{su} | Setup time ⁽⁴⁾ | LS_WDATA valid before rising edge of LS_CLK (differential) | | | 1.5 | ns |
| t_h | Hold time ⁽⁴⁾ | LS_WDATA valid after rising edge of LS_CLK (differential) | | | 1.5 | ns |
| HIGH SPEED SERIAL INTERFACE (HSSI) | | | | | | |
| t_r | Rise time ⁽⁵⁾ | from -A1 to A1 minimum eye height specification | 50 | | 100 | ps |
| t_f | Fall time ⁽⁵⁾ | from A1 to -A1 minimum eye height specification | 50 | | 100 | ps |
| $t_{W(H)}$ | Pulse duration high ⁽⁶⁾ | DCLK. 50% to 50% reference points | 0.275 | | | ns |
| $t_{W(L)}$ | Pulse duration low ⁽⁶⁾ | DCLK. 50% to 50% reference points | 0.275 | | | ns |

- (1) See [Figure 6-9](#) for rise time and fall time for LVC MOS.
- (2) See [Figure 6-4](#) for rise time and fall time for LSIF.
- (3) See [Figure 6-4](#) for pulse duration high and low time for LSIF.
- (4) See [Figure 6-4](#) for setup and hold time for LSIF.
- (5) See [Figure 6-12](#) for rise time and fall time for HSSI.
- (6) See [Figure 6-12](#) for pulse duration high and low for HSSI.

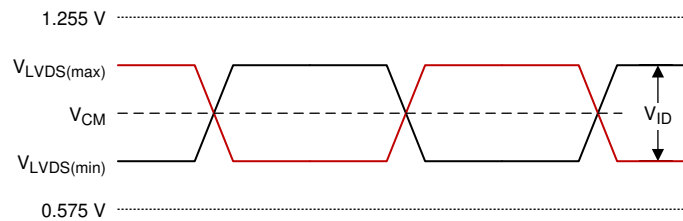


Figure 6-3. LSIF Waveform Requirements

$$V_{LVDS(max)} = V_{CM(max)} + \left| \frac{1}{2} \times V_{ID(max)} \right|$$

$$V_{LVDS(min)} = V_{CM(min)} - \left| \frac{1}{2} \times V_{ID(max)} \right|$$

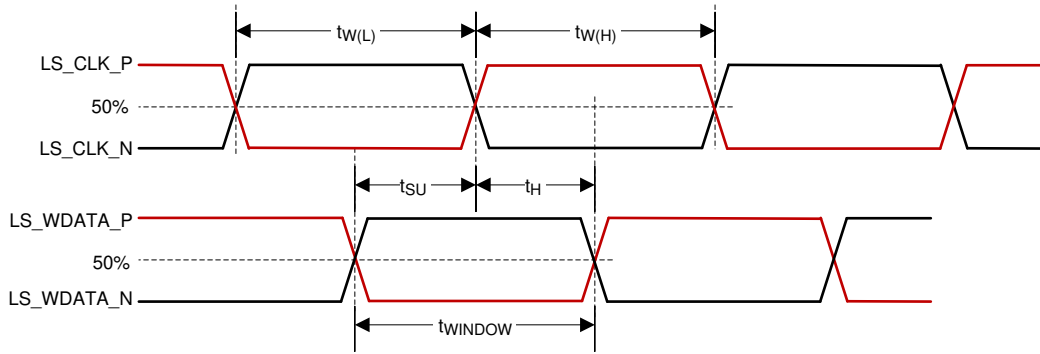


Figure 6-4. LSIF Timing Requirements

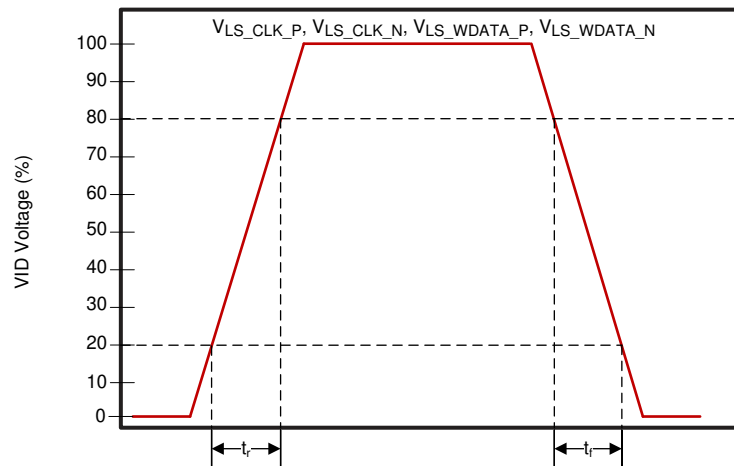


Figure 6-5. LSIF Rise, Fall Time Slew

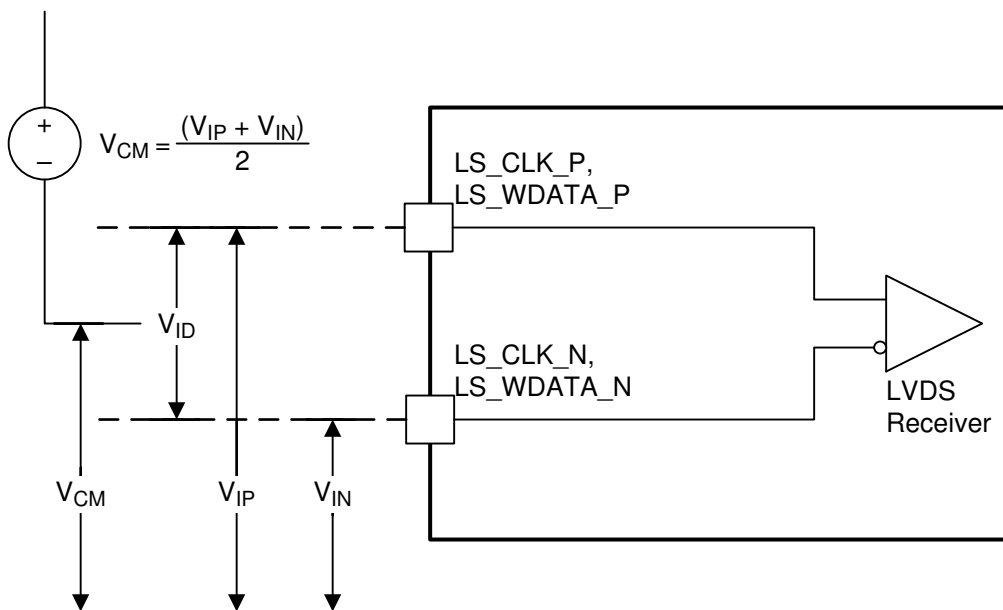


Figure 6-6. LSIF Voltage Requirements

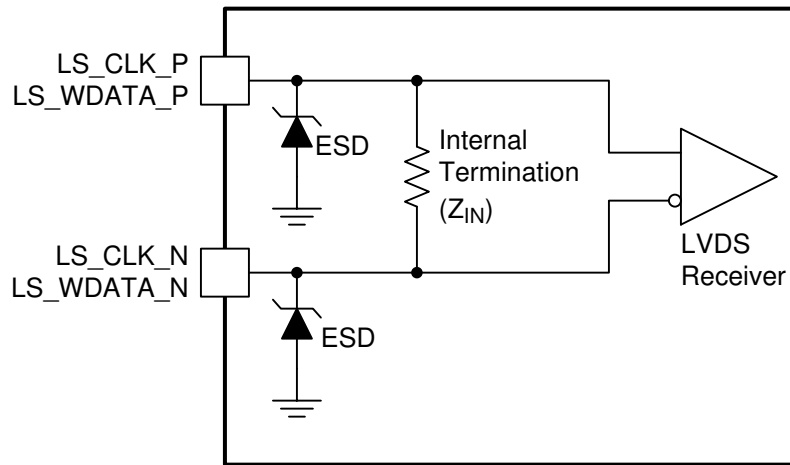


Figure 6-7. LSIF Equivalent Input

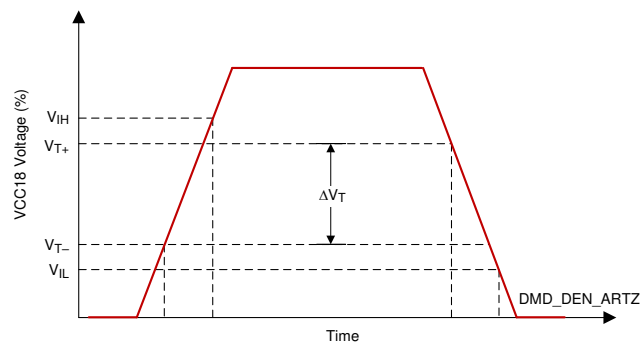


Figure 6-8. LVCMOS Input Hysteresis

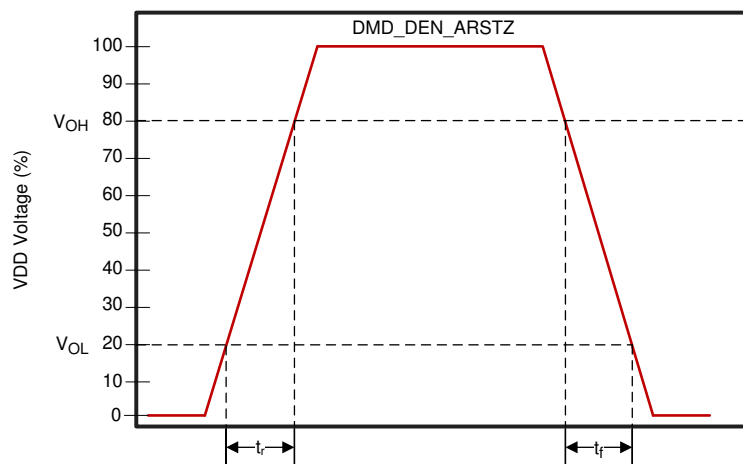


Figure 6-9. LVCMOS Rise, Fall Time Slew Rate

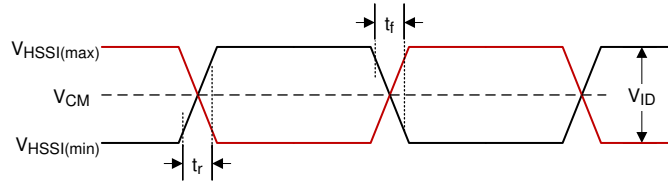


Figure 6-10. HSSI Waveform Requirements

$$V_{HSSI(max)} = V_{CM(max)} + \left| \frac{1}{2} \times V_{ID(max)} \right|$$

$$V_{HSSI(min)} = V_{CM(min)} - \left| \frac{1}{2} \times V_{ID(max)} \right|$$

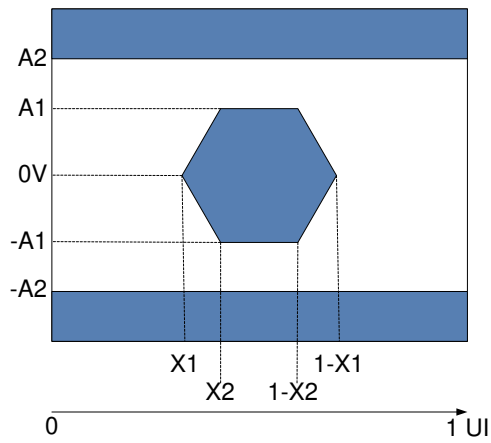


Figure 6-11. HSSI Eye Characteristics

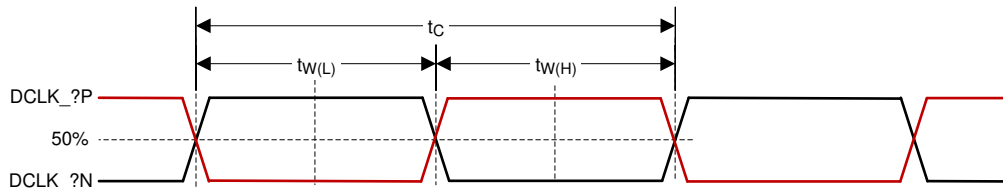


Figure 6-12. HSSI CLK Characteristics

6.9 System Mounting Interface Loads

| PARAMETER | MIN | TYP | MAX | UNIT |
|--|-----|-----|-----|------|
| Thermal interface area ⁽¹⁾ | | | 100 | N |
| Electrical interface area ⁽¹⁾ | | | 245 | N |

(1) The load should be uniformly applied within the area shown in [Figure 6-13](#).

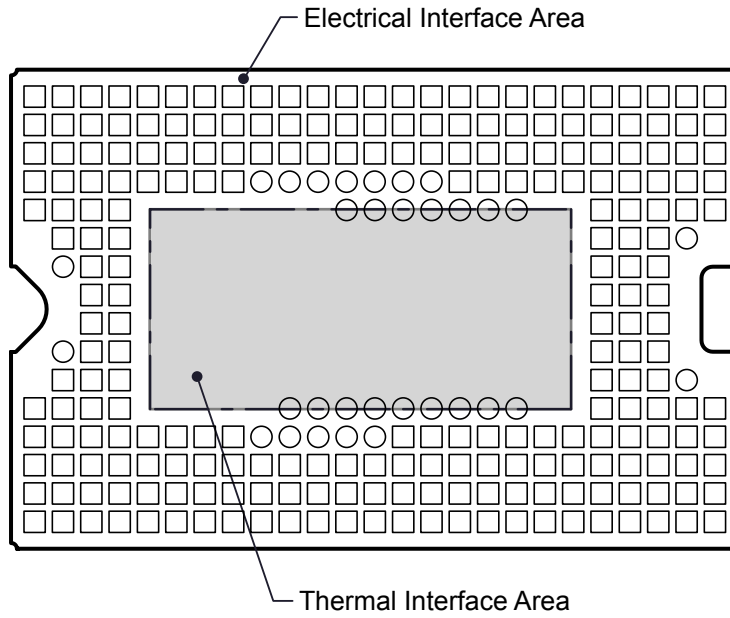


Figure 6-13. System Mounting Interface Loads

6.10 Micromirror Array Physical Characteristics

| PARAMETER DESCRIPTION | | VALUE | UNIT |
|--|--|--------|-------------------|
| Number of active columns ^{(1) (2)} | M | 1920 | micromirrors |
| Number of active rows ^{(1) (2)} | N | 1080 | micromirrors |
| Micromirror (pixel) pitch ⁽¹⁾ | P | 5.4 | μm |
| Micromirror active array width ⁽¹⁾ | Micromirror pitch × number of active columns | 10.368 | mm |
| Micromirror active array height ⁽¹⁾ | Micromirror pitch × number of active rows | 5.832 | mm |
| Micromirror active border ⁽³⁾ | Pond of micromirror (POM) | 20 | micromirrors/side |

- (1) See Figure 6-14.
- (2) The fast switching speed of the DMD micromirrors combined with advanced DLP image processing algorithms enables each micromirror to display four distinct pixels on the screen during every frame, resulting in a full 3840 × 2160 pixel image being displayed.
- (3) The structure and qualities of the border around the active array includes a band of partially functional micromirrors referred to as the *Pond Of Micromirrors* (POM). These micromirrors are structurally and/or electrically prevented from tilting toward the bright or ON state but still require an electrical bias to tilt toward the OFF state.

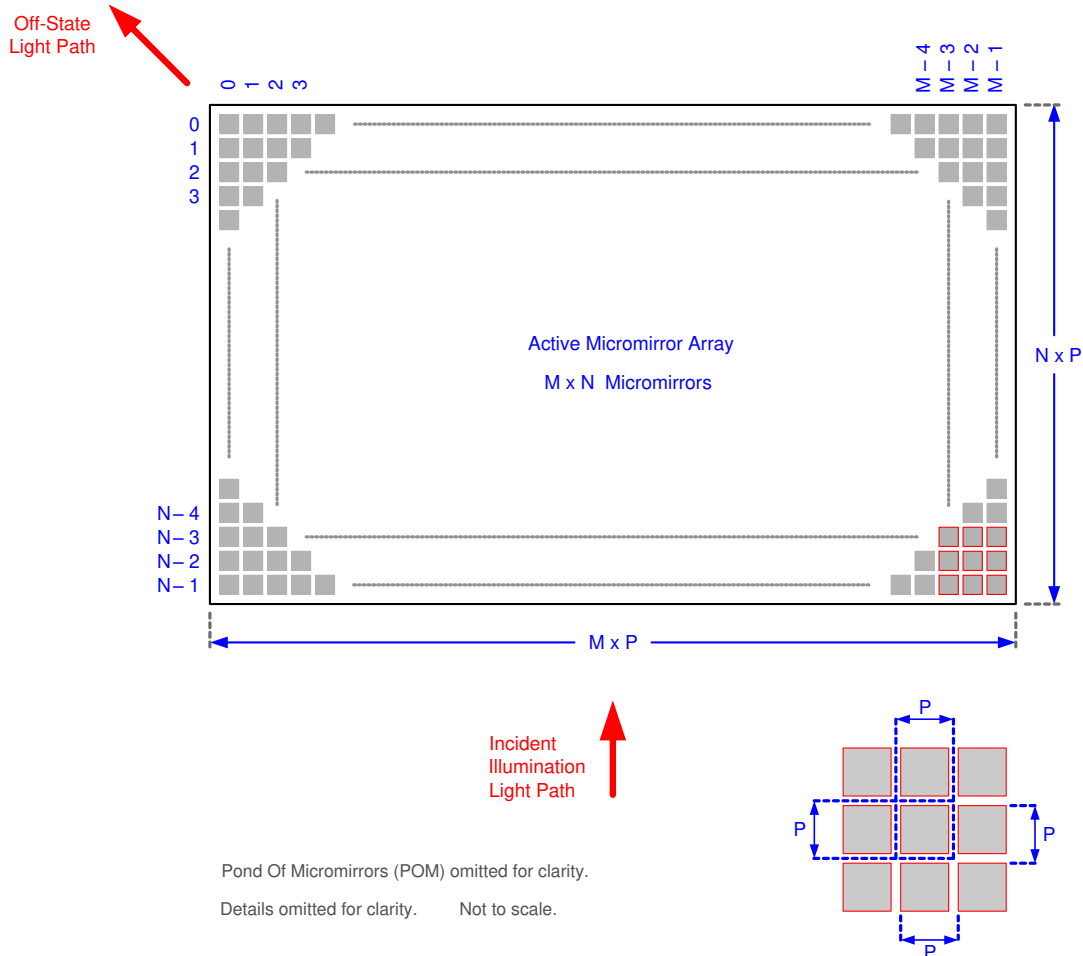


Figure 6-14. Micromirror Array Physical Characteristics

6.11 Micromirror Array Optical Characteristics

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|--|--------------------------------|------|-----|-----|--------------|
| Micromirror tilt angle | | Landed state ⁽¹⁾ | | 17 | | degrees |
| Micromirror tilt angle tolerance ^{(2) (3) (4) (5)} | | | -1.4 | | 1.4 | degrees |
| Micromirror tilt direction ^{(6) (7)} | | Landed ON state | | 270 | | degrees |
| Micromirror tilt direction ^{(6) (7)} | | Landed OFF state | | 180 | | degrees |
| Micromirror crossover time ⁽⁸⁾ | | Typical performance | | 1 | 3 | µs |
| Micromirror switching time ⁽⁹⁾ | | Typical performance | 6 | | | |
| Image performance ⁽¹⁰⁾ | Bright pixel(s) in active area ⁽¹¹⁾ | Gray 10 Screen ⁽¹²⁾ | | | 0 | micromirrors |
| | Bright pixel(s) in the POM ⁽¹³⁾ | Gray 10 Screen ⁽¹²⁾ | | | 1 | |
| | Dark pixel(s) in the active area ⁽¹⁴⁾ | White Screen | | | 4 | |
| | Adjacent pixel(s) ⁽¹⁵⁾ | Any Screen | | | 0 | |
| | Unstable pixel(s) in active area ⁽¹⁶⁾ | Any Screen | | | 0 | |

- (1) Measured relative to the plane formed by the overall micromirror array.
- (2) Additional variation exists between the micromirror array and the package datums.
- (3) Represents the landed tilt angle variation relative to the nominal landed tilt angle.
- (4) Represents the variation that can occur between any two individual micromirrors, located on the same device or located on different devices.
- (5) For some applications, it is critical to account for the micromirror tilt angle variation in the overall system optical design. With some system optical designs, the micromirror tilt angle variation within a device may result in perceivable non-uniformities in the light field reflected from the micromirror array. With some system optical designs, the micromirror tilt angle variation between devices may result in colorimetry variations, system efficiency variations or system contrast variations.
- (6) When the micromirror array is landed (not parked), the tilt direction of each individual micromirror is dictated by the binary contents of the CMOS memory cell associated with each individual micromirror. A binary value of 1 results in a micromirror landing in the ON State direction. A binary value of 0 results in a micromirror landing in the OFF State direction. See [Figure 6-15](#).
- (7) Micromirror tilt direction is measured as in a typical polar coordinate system: Measuring counter-clockwise from a 0° degree reference which is aligned with the +X Cartesian axis.
- (8) The time required for a micromirror to nominally transition from one landed state to the opposite landed state.
- (9) The minimum time between successive transitions of a micromirror.
- (10) Conditions of Acceptance: All DMD image quality returns will be evaluated using the following projected image test conditions:
 - Test set degamma shall be linear
 - Test set brightness and contrast shall be set to nominal
 - The diagonal size of the projected image shall be a minimum of 20 inches
 - The projections screen shall be 1X gain
 - The projected image shall be inspected from a 38 inch minimum viewing distance
 - The image shall be in focus during all image quality tests
- (11) Bright pixel definition: A single pixel or mirror that is stuck in the ON position and is visibly brighter than the surrounding pixels
- (12) Gray 10 screen definition: All areas of the screen are colored with the following settings:
 - Red = 10/255
 - Green = 10/255
 - Blue = 10/255
- (13) POM definition: Rectangular border of off-state mirrors surrounding the active area
- (14) Dark pixel definition: A single pixel or mirror that is stuck in the OFF position and is visibly darker than the surrounding pixels
- (15) Adjacent pixel definition: Two or more stuck pixels sharing a common border or common point, also referred to as a cluster
- (16) Unstable pixel definition: A single pixel or mirror that does not operate in sequence with parameters loaded into memory. The unstable pixel appears to be flickering asynchronously with the image

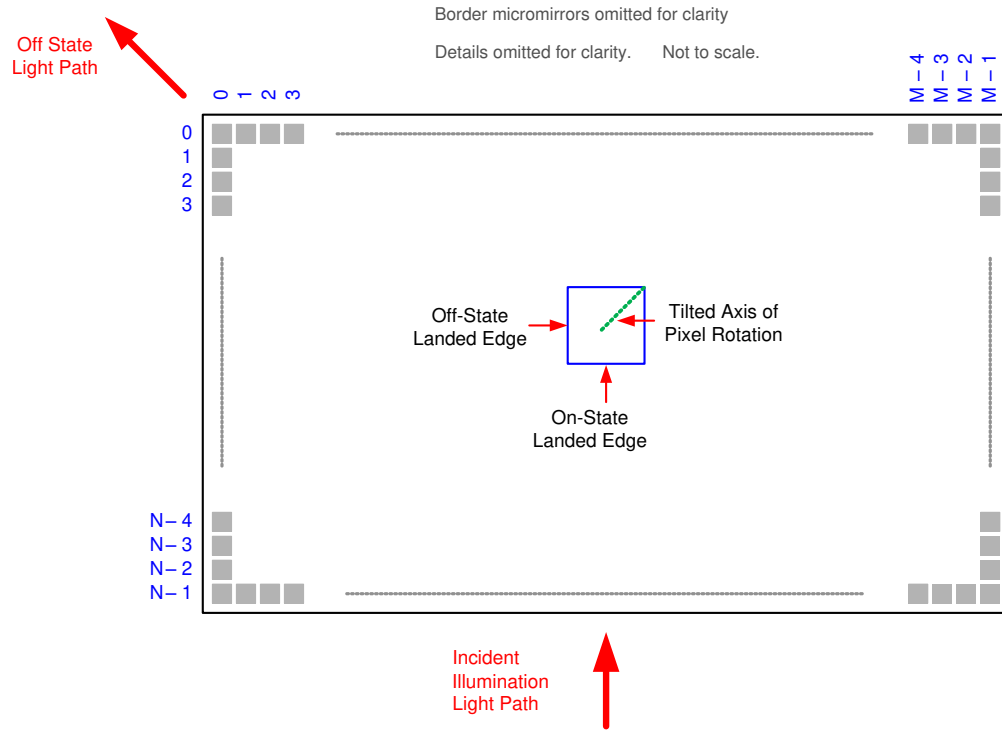


Figure 6-15. Micromirror Landed Orientation and Tilt

6.12 Window Characteristics

| DESCRIPTION ⁽¹⁾ | | MIN | TYP | MAX |
|---|--|-----|--------------------|-----|
| Window material | | | Corning Eagle XG | |
| Window refractive index | At wavelength 546.1 nm | | 1.5119 | |
| Window aperture ⁽²⁾ | | | See ⁽²⁾ | |
| Illumination overfill ⁽³⁾ | | | See ⁽³⁾ | |
| Window transmittance, single-pass through both surfaces and glass | Minimum within the wavelength range 420 nm to 680 nm. Applies to all angles 0° to 30° AOI ⁽⁴⁾ | 97% | | |
| | Average over the wavelength range 420 nm to 680 nm. Applies to all angles 30° to 45° AOI ⁽⁴⁾ | 97% | | |

- (1) See [Section 7.5](#) for more information.
- (2) See the package mechanical characteristics for details regarding the size and location of the window aperture.
- (3) The active area of the DLP471TP device is surrounded by an aperture on the inside of the DMD window surface that masks structures of the DMD device assembly from normal view. The aperture is sized to anticipate several optical conditions. Overfill light illuminating the area outside the active array can scatter and create adverse effects to the performance of an end application using the DMD. The illumination optical system should be designed to limit light flux incident outside the active array to less than 10% of the average flux level in the active area. Depending on the particular system's optical architecture and assembly tolerances, the amount of overfill light on the outside of the active array may cause system performance degradation.
- (4) Angle of incidence (AOI) is the angle between an incident ray and the normal to a reflecting or refracting surface.

6.13 Chipset Component Usage Specification

Reliable function and operation of the DLP471TP DMD requires that it be used in conjunction with the other components of the applicable DLP chipset, including those components that contain or implement TI DMD control technology. TI DMD control technology consists of the TI technology and devices used for operating or controlling a DLP DMD.

Note

TI assumes no responsibility for image quality artifacts or DMD failures caused by optical system operating conditions exceeding limits described previously.

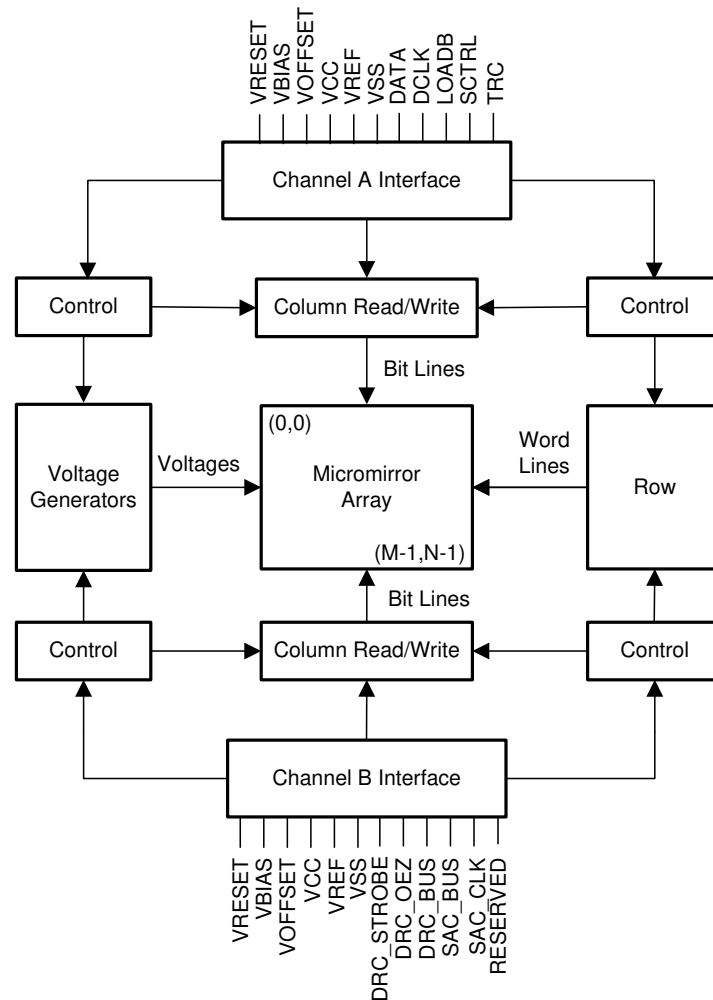
7 Detailed Description

7.1 Overview

The DMD is a 0.47-inch diagonal spatial light modulator which consists of an array of highly reflective aluminum micromirrors. The DMD is an electrical input, optical output micro-optical-electrical-mechanical system (MOEMS). The fast switching speed of the DMD micromirrors combined with advanced DLP image processing algorithms enables each micromirror to display four distinct pixels on the screen during every frame, resulting in a full 3840 × 2160 pixel image being displayed. The electrical interface is low voltage differential signaling (LVDS). The DMD consists of a two-dimensional array of 1-bit CMOS memory cells. The array is organized in a grid of M memory cell columns by N memory cell rows. Refer to the [Section 7.2](#). The positive or negative deflection angle of the micromirrors can be individually controlled by changing the address voltage of underlying CMOS addressing circuitry and micromirror reset signals (MBRST).

The DLP 0.47" 4K UHD chipset is comprised of the DLP471TP DMD, DLPC6540 display controller, and the [DLPA3005](#) PMIC and the LED driver. To ensure reliable operation, the DLP471TP DMD must always be used with the DLP display controller and the PMIC specified in the chipset.

7.2 Functional Block Diagram



7.3 Feature Description

7.3.1 Power Interface

The DMD requires 4 DC voltages: 1.8 V source, V_{OFFSET} , V_{RESET} , and V_{BIAS} . In a typical LED-based system, 1.8 V is provided by a [TPS54320](#) and the V_{OFFSET} , V_{RESET} , and V_{BIAS} is managed by the [DLPA3005](#) PMIC and LED driver.

7.3.2 Timing

The data sheet provides timing at the device pin. For output timing analysis, the tester pin electronics and its transmission line effects must be taken into account. Timing reference loads are not intended to be precise representations of any particular system environment or depiction of the actual load presented by a production test. System designers should use IBIS or other simulation tools to correlate the timing reference load to a system environment. The load capacitance value stated is only for characterization and measurement of AC timing signals. This load capacitance value does not indicate the maximum load the device is capable of driving.

7.4 Device Functional Modes

DMD functional modes are controlled by the DLPC6540 display controller. See the DLPC6540 display controller data sheet or contact a TI applications engineer.

7.5 Optical Interface and System Image Quality Considerations

TI assumes no responsibility for end-equipment optical performance. Achieving the desired end-equipment optical performance involves making trade-offs between numerous component and system design parameters. Optimizing system optical performance and image quality strongly relate to optical system design parameter trades. Although it is not possible to anticipate every conceivable application, projector image quality and optical performance is contingent on compliance to the optical system operating conditions described in the following sections.

7.5.1 Numerical Aperture and Stray Light Control

The angle defined by the numerical aperture of the illumination and projection optics at the DMD optical area should be the same. This angle should not exceed the nominal device micromirror tilt angle unless appropriate apertures are added in the illumination and/or projection pupils to block out flat-state and stray light from the projection lens. The micromirror tilt angle defines DMD capability to separate the "ON" optical path from any other light path, including undesirable flat-state specular reflections from the DMD window, DMD border structures, or other system surfaces near the DMD such as prism or lens surfaces. If the numerical aperture exceeds the micromirror tilt angle, or if the projection numerical aperture angle is more than two degrees larger than the illumination numerical aperture angle (and vice versa), contrast degradation and objectionable artifacts in the display border and/or active area could occur.

7.5.2 Pupil Match

TI's optical and image quality specifications assume that the exit pupil of the illumination optics is nominally centered within 2° of the entrance pupil of the projection optics. Misalignment of pupils can create objectionable artifacts in the display border and/or active area, which may require additional system apertures to control, especially if the numerical aperture of the system exceeds the pixel tilt angle.

7.5.3 Illumination Overfill

The active area of the device is surrounded by an aperture on the inside DMD window surface that masks structures of the DMD chip assembly from normal view, and is sized to anticipate several optical operating conditions. Overfill light illuminating the window aperture can create artifacts from the edge of the window aperture opening and other surface anomalies that may be visible on the screen. The illumination optical system should be designed to limit light flux incident anywhere on the window aperture from exceeding approximately 10% of the average flux level in the active area. Depending on the particular system optical architecture, overfill light may have to be further reduced below the suggested 10% level in order to be acceptable.

7.6 Micromirror Array Temperature Calculation

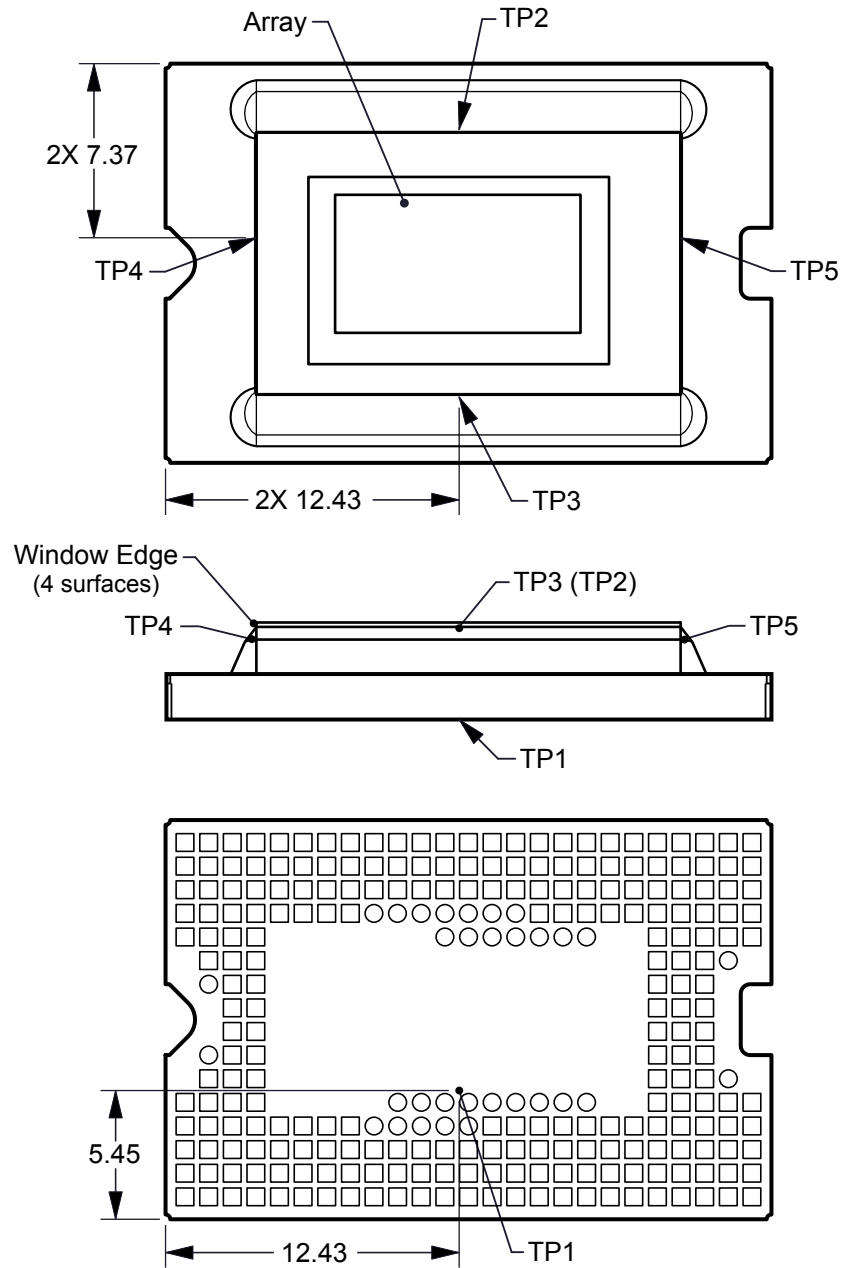


Figure 7-1. DMD Thermal Test Points

Micromirror array temperature cannot be measured directly, therefore it must be computed analytically from measurement points on the outside of the package, the package thermal resistance, the electrical power, and the illumination heat load. The relationship between array temperature and the reference ceramic temperature (thermal test TP1 in [Figure 7-1](#)) is provided by the following equations:

$$T_{\text{ARRAY}} = T_{\text{CERAMIC}} + (Q_{\text{ARRAY}} \times R_{\text{ARRAY-TO-CERAMIC}})$$

$$Q_{\text{ARRAY}} = Q_{\text{ELECTRICAL}} + Q_{\text{ILLUMINATION}}$$

where

- T_{ARRAY} = Computed array temperature (°C)
- T_{CERAMIC} = Measured ceramic temperature (°C) (TP1 location)
- $R_{\text{ARRAY-TO-CERAMIC}}$ = Thermal resistance of package specified in [Section 6.5](#) from array to ceramic TP1 (°C/Watt)
- Q_{ARRAY} = Total (electrical + absorbed) DMD power on the array (Watts)
- $Q_{\text{ELECTRICAL}}$ = Nominal electrical power
- $Q_{\text{ILLUMINATION}} = (C_{\text{L2W}} \times \text{SL})$
- C_{L2W} = Conversion constant for screen lumens to power on DMD (Watts/Lumen)
- SL = Measured screen Lumens

The electrical power dissipation of the DMD is variable and depends on the voltages, data rates, and operating frequencies. A nominal electrical power dissipation to use when calculating array temperature is 2.5 W. The absorbed power from the illumination source is variable and depends on the operating state of the micromirrors and the intensity of the light source. The equations shown above are valid for a 1-chip DMD system with projection efficiency from the DMD to the screen of 87%.

The conversion constant C_{L2W} is calculated to be 0.00266 W/lm based on array characteristics. It assumes a spectral efficiency of 300 lumens/Watt for the projected light and illumination distribution of 83.7% on the active array, and 16.3% on the array border.

The sample calculation for a typical projection application is as follows:

$$\text{SL} = 1500 \text{ lm (measured)}$$

$$T_{\text{CERAMIC}} = 55.0^\circ\text{C (measured)}$$

$$C_{\text{L2W}} = 0.00266 \text{ W/lm}$$

$$Q_{\text{ELECTRICAL}} = 2.5 \text{ W}$$

$$Q_{\text{ARRAY}} = 2.5 \text{ W} + (0.00266 \text{ W/lm} \times 1500 \text{ lm}) = 6.49 \text{ W}$$

$$T_{\text{ARRAY}} = 55.0^\circ\text{C} + (6.49 \text{ W} \times 1.0^\circ\text{C/W}) = 61.49^\circ\text{C}$$

7.7 Micromirror Landed-On/Landed-Off Duty Cycle

7.7.1 Definition of Micromirror Landed-On/Landed-Off Duty Cycle

The micromirror landed-on/landed-off duty cycle (landed duty cycle) denotes the percentage of time that an individual micromirror is landed in the ON state versus the amount of time the same micromirror is landed in the OFF state.

For example, a landed duty cycle of 100/0 indicates that the referenced pixel is in the ON state 100% of the time (and in the OFF state 0% of the time); whereas 0/100 would indicate that the pixel is in the OFF state 100% of the time. Likewise, 50/50 indicates that the pixel is ON for 50% of the time (and OFF for 50% of the time).

Note that when assessing landed duty cycle, the time spent switching from one state (ON or OFF) to the other state (OFF or ON) is considered negligible and is thus ignored.

Since a micromirror can only be landed in one state or the other (ON or OFF), the two numbers (percentages) always add to 100.

7.7.2 Landed Duty Cycle and Useful Life of the DMD

Knowing the long-term average landed duty cycle (of the end product or application) is important because subjecting all (or a portion) of the DMD micromirror array (also called the active array) to an asymmetric landed duty cycle for a prolonged period of time can reduce the DMD useful life.

Note that it is the symmetry/asymmetry of the landed duty cycle that is of relevance. The symmetry of the landed duty cycle is determined by how close the two numbers (percentages) are to being equal. For example, a landed duty cycle of 50/50 is perfectly symmetrical whereas a landed duty cycle of 100/0 or 0/100 is perfectly asymmetrical.

7.7.3 Landed Duty Cycle and Operational DMD Temperature

Operational DMD temperature and landed duty cycle interact to affect DMD useful life, and this interaction can be exploited to reduce the impact that an asymmetrical landed duty cycle has on the DMD useful life. This is quantified in the de-rating curve shown in [Figure 6-1](#). The importance of this curve is that:

- All points along this curve represent the same useful life.
- All points above this curve represent lower useful life (and the further away from the curve, the lower the useful life).
- All points below this curve represent higher useful life (and the further away from the curve, the higher the useful life).

In practice, this curve specifies the maximum operating DMD temperature that the DMD should be operated at for a given long-term average landed duty cycle.

7.7.4 Estimating the Long-Term Average Landed Duty Cycle of a Product or Application

During a given period of time, the landed duty cycle of a given pixel follows from the image content being displayed by that pixel.

For example, in the simplest case, when displaying pure-white on a given pixel for a given time period, that pixel operates under a 100/0 landed duty cycle during that time period. Likewise, when displaying pure-black, the pixel operates under a 0/100 landed duty cycle.

Between the two extremes (ignoring for the moment color and any image processing that may be applied to an incoming image), the landed duty cycle tracks one-to-one with the gray scale value, as shown in [Table 7-1](#).

Table 7-1. Grayscale Value and Landed Duty Cycle

| GRAYSCALE VALUE | LANDED DUTY CYCLE |
|-----------------|-------------------|
| 0% | 0/100 |
| 10% | 10/90 |
| 20% | 20/80 |
| 30% | 30/70 |
| 40% | 40/60 |
| 50% | 50/50 |
| 60% | 60/40 |
| 70% | 70/30 |
| 80% | 80/20 |
| 90% | 90/10 |
| 100% | 100/0 |

Accounting for color rendition (but still ignoring image processing) requires knowing both the color intensity (from 0% to 100%) for each constituent primary color (red, green, and/or blue) for the given pixel as well as the color cycle time for each primary color, where “color cycle time” is the total percentage of the frame time that a given primary must be displayed in order to achieve the desired white point.

Use [Equation 1](#) to calculate the landed duty cycle of a given pixel during a given time period

$$\text{Landed Duty Cycle} = (\text{Red_Cycle_}\% \times \text{Red_Scale_Value}) + (\text{Green_Cycle_}\% \times \text{Green_Scale_Value}) + (\text{Blue_Cycle_}\% \times \text{Blue_Scale_Value}) \quad (9)$$

where

- Red_Cycle_%, represents the percentage of the frame time that red is displayed to achieve the desired white point
- Green_Cycle_% represents the percentage of the frame time that green is displayed to achieve the desired white point
- Blue_Cycle_%, represents the percentage of the frame time that blue is displayed to achieve the desired white point

For example, assume that the red, green, and blue color cycle times are 30%, 50%, and 20% respectively (in order to achieve the desired white point), then the landed duty cycle for various combinations of red, green, blue color intensities would be as shown in [Table 7-2](#) and [Table 7-3](#).

Table 7-2. Example Landed Duty Cycle for Full-Color, Color Percentage

| CYCLE PERCENTAGE | | |
|------------------|-------|------|
| RED | GREEN | BLUE |
| 30% | 50% | 20% |

Table 7-3. Example Landed Duty Cycle for Full-Color

| SCALE VALUE | | | LANDED DUTY CYCLE |
|-------------|-------|------|-------------------|
| RED | GREEN | BLUE | |
| 0% | 0% | 0% | 0/100 |
| 100% | 0% | 0% | 50/50 |
| 0% | 100% | 0% | 20/80 |
| 0% | 0% | 100% | 30/70 |
| 12% | 0% | 0% | 6/94 |
| 0% | 35% | 0% | 7/93 |
| 0% | 0% | 60% | 18/82 |
| 100% | 100% | 0% | 70/30 |
| 0% | 100% | 100% | 50/50 |
| 100% | 0% | 100% | 80/20 |
| 12% | 35% | 0% | 13/87 |
| 0% | 35% | 60% | 25/75 |
| 12% | 0% | 60% | 24/76 |
| 100% | 100% | 100% | 100/0 |

The last factor to account for in estimating the landed duty cycle is any applied image processing. Within the DLPC6540 controller, the gamma function affects the landed duty cycle.

Gamma is a power function of the form $\text{Output_Level} = A \times \text{Input_Level}^{\text{Gamma}}$, where A is a scaling factor that is typically set to 1.

In the DLPC6540 controller, gamma is applied to the incoming image data on a pixel-by-pixel basis. A typical gamma factor is 2.2, which transforms the incoming data as shown in [Figure 7-2](#).

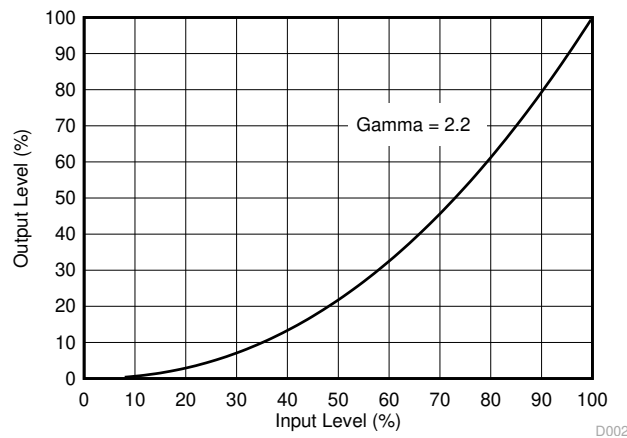


Figure 7-2. Example of Gamma = 2.2

From [Figure 7-2](#), if the gray scale value of a given input pixel is 40% (before gamma is applied), then gray scale value will be 13% after gamma is applied. Therefore, it can be seen that since gamma has a direct impact displayed gray scale level of a pixel, it also has a direct impact on the landed duty cycle of a pixel.

Consideration must also be given to any image processing which occurs before the DLPC6540 controller.

8 Application and Implementation

Note

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

8.1 Application Information

DMDs are spatial light modulators which reflect incoming light from an illumination source to one of two directions, with the primary direction being into a projection or collection optic. Each application is derived primarily from the optical architecture of the system and the format of the data coming into the DLPC6540 controller. The high tilt pixel in the bottom-illuminated DMD increases brightness performance and enables a smaller system footprint for thickness constrained applications. Typical applications using the DLP471TP include mobile smart TV and digital signage.

DMD power-up and power-down sequencing is strictly controlled by the DLPA3005. Refer to [Section 9](#) for power-up and power-down specifications. To ensure reliable operation, the DLP471TP DMD must always be used with DLPC6540 controller and a DLPA3005 PMIC/LED driver.

8.2 Typical Application

The DLP471TP DMD combined with DLPC6540 digital controller and a power management device provides full 4K UHD resolution for bright, colorful display applications. See [Figure 8-1](#), a block diagram showing the system components needed along with the LED configuration of the DLP 0.47" 4K UHD chipset. The components include the DLP471TP DMD, DLPC6540 display controller and the DLPA3005 PMIC and LED driver.

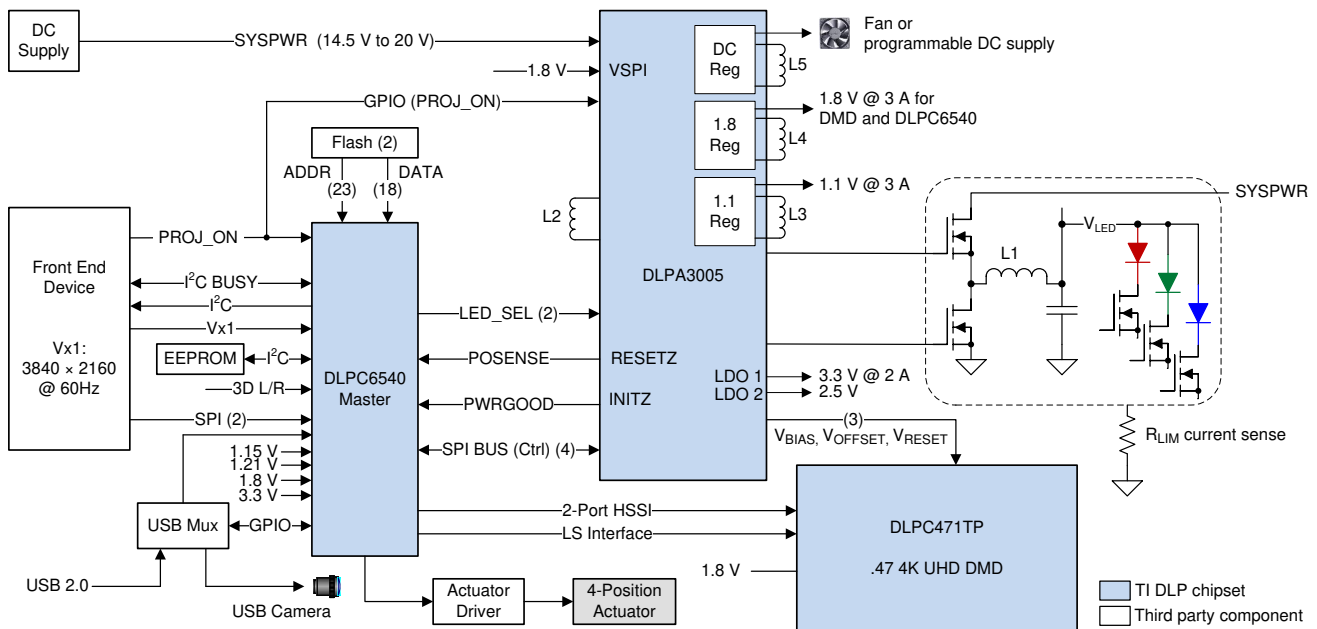


Figure 8-1. Typical 4K UHD LED Application Diagram

8.2.1 Design Requirements

Other core components of the display system include an illumination source, an optical engine for the illumination and projection optics, other electrical and mechanical components, and software. The type of illumination used and desired brightness will have a major effect on the overall system design and size.

The display system uses the DLP471TP as the core imaging device and contains a 0.47-inch array of micromirrors. The DLPC6540 controller is the digital interface between the DMD and the rest of the system, taking digital input from front end receiver and driving the DMD over a high-speed interface. The [DLPA3005](#) PMIC serves as a voltage regulator for the DMD, controller, and LED illumination functionality.

8.2.2 Detailed Design Procedure

For a complete DLP system, an optical module or light engine is required that contains the DLP471TP DMD, associated illumination sources, optical elements, and necessary mechanical components.

To ensure reliable operation, the DMD must always be used with DLPC6540 display controller and the [DLPA3005](#) PMIC and LED driver . Refer to [PCB Design Requirements for TI DLP Pico TRP Digital Micromirror Devices](#) for the DMD board design and manufacturing handling of the DMD sub assemblies.

8.2.3 Application Curves

The typical LED-current-to-luminance relationship when LED illumination is utilized is shown in [Figure 8-2](#).

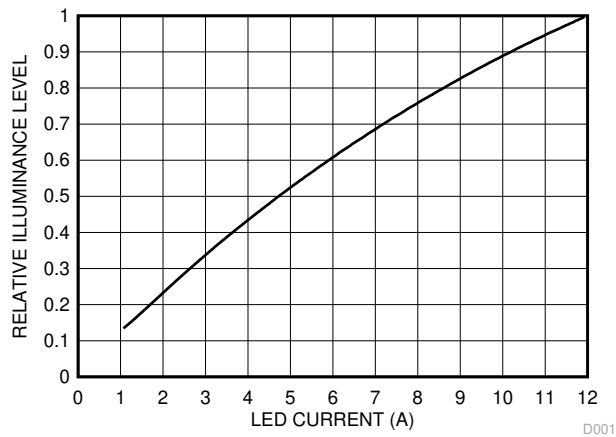


Figure 8-2. Luminance vs. Current

8.3 Temperature Sensor Diode

The software application contains functions to configure the [TMP411](#) to read the DLP471TP DMD temperature sensor diode. This data can be leveraged by the customer to incorporate additional functionality in the overall system design such as adjusting illumination, fan speeds, etc. All communication between the [TMP411](#) and the DLPC6540 controller will be completed using the I²C interface. The [TMP411](#) connects to the DMD via pins outlined in [#unique_47/unique_47_Connect_42_PACKAGE_PINOUT_S317](#).

9 Power Supply Recommendations

The following power supplies are all required to operate the DMD:

- V_{SS}
- V_{BIAS}
- V_{DD}
- V_{DDA}
- V_{OFFSET}
- V_{RESET}

DMD power-up and power-down sequencing is strictly controlled by the DLP display controller.

CAUTION

For reliable operation of the DMD, the following power supply sequencing requirements must be followed. Failure to adhere to any of the prescribed power-up and power-down requirements may affect device reliability. See the DMD power supply sequencing requirements in [Figure 9-1](#).

V_{BIAS} , V_{DD} , V_{DDA} , V_{OFFSET} , and V_{RESET} power supplies must be coordinated during power-up and power-down operations. Failure to meet any of the below requirements will result in a significant reduction in the DMD reliability and lifetime. Common ground V_{SS} must also be connected.

Table 9-1. Power Supply Sequence Requirements

| SYMBOL | PARAMETER | DESCRIPTION | MIN | TYP | MAX | UNIT |
|--------------|----------------------|--|-----|-----|-----|------|
| t_{DELAY} | Delay requirement | from V_{OFFSET} power up to V_{BIAS} power up | 2 | | | ms |
| V_{OFFSET} | Supply voltage level | at beginning of power-up sequence delay ⁽¹⁾ | | | 6 | V |
| V_{BIAS} | Supply voltage level | at end of power-up sequence delay ⁽¹⁾ | | | 6 | V |

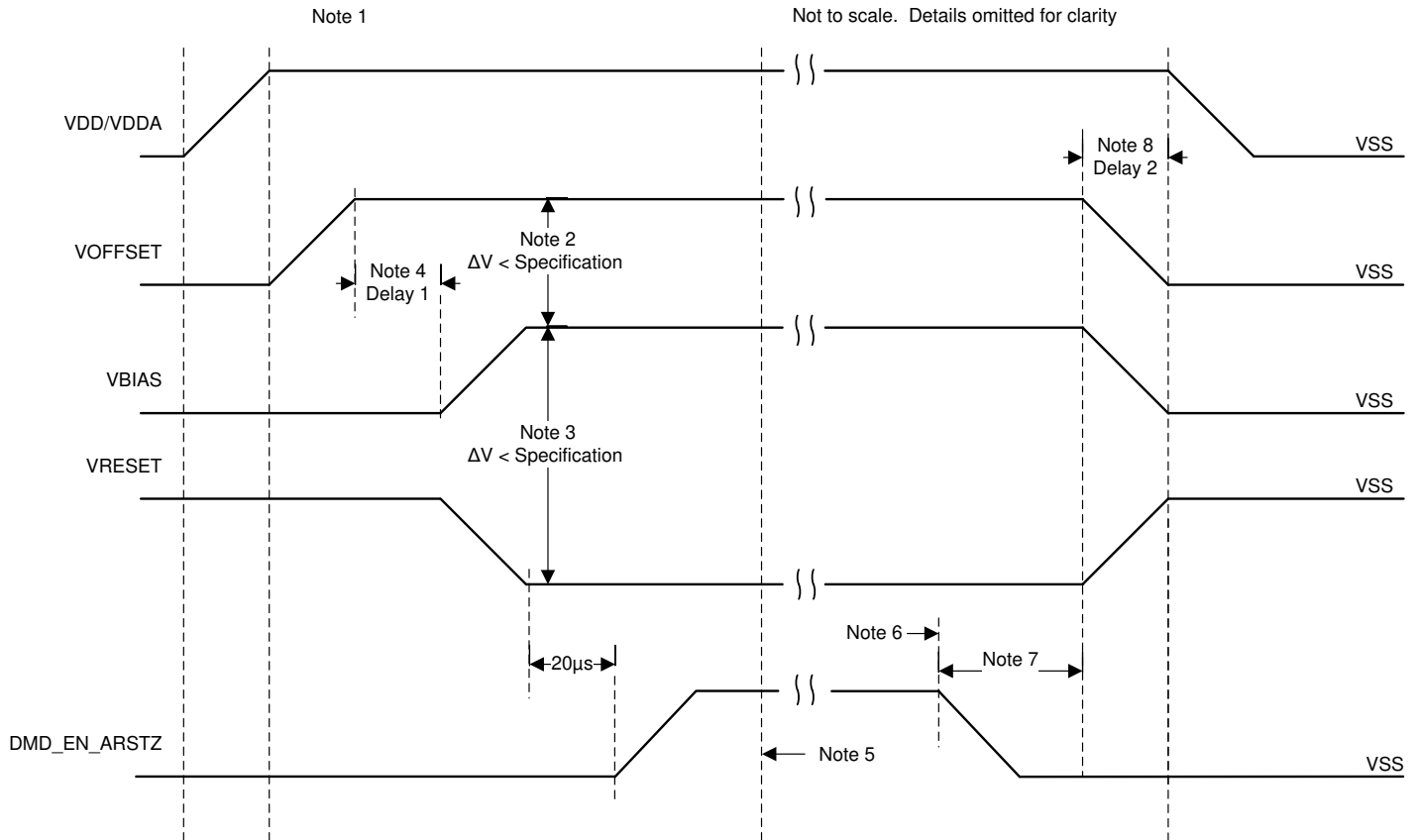
(1) See [Figure 9-1](#), Power-Up Sequence Delay Requirement.

9.1 DMD Power Supply Power-Up Procedure

- During power-up, V_{DD} and V_{DDA} must always start and settle before V_{OFFSET} plus Delay1 specified in [Table 9-2](#), V_{BIAS} , and V_{RESET} voltages are applied to the DMD.
- During power-up, it is a strict requirement that the voltage difference between V_{BIAS} and V_{OFFSET} must be within the specified limit shown in [Section 6.4](#).
- During power-up, there is no requirement for the relative timing of V_{RESET} with respect to V_{BIAS} .
- Power supply slew rates during power-up are flexible, provided that the transient voltage levels follow the requirements specified in [Section 6.1](#), in [Section 6.4](#), and in [Figure 9-1](#).
- During power-up, LVCMOS input pins must not be driven high until after V_{DD} have settled at operating voltages listed in [Section 6.4](#).

9.2 DMD Power Supply Power-Down Procedure

- During power-down, V_{DD} and V_{DDA} must be supplied until after V_{BIAS} , V_{RESET} , and V_{OFFSET} are discharged to within the specified limit of ground. See [Table 9-2](#).
- During power-down, it is a strict requirement that the voltage difference between V_{BIAS} and V_{OFFSET} must be within the specified limit shown in [Section 6.4](#).
- During power-down, there is no requirement for the relative timing of V_{RESET} with respect to V_{BIAS} .
- Power supply slew rates during power-down are flexible, provided that the transient voltage levels follow the requirements specified in [Section 6.1](#), in [Section 6.4](#), and in [Figure 9-1](#).
- During power-down, LVCMOS input pins must be less than specified in [Section 6.4](#).



- A. See [#unique_47/unique_47_Connect_42_PACKAGE_PINOUT_S317](#) for the *Pin Functions Table*.
- B. To prevent excess current, the supply voltage difference $|V_{\text{OFFSET}} - V_{\text{BIAS}}|$ must be less than the specified limit in [Section 6.4](#).
- C. To prevent excess current, the supply difference $|V_{\text{BIAS}} - V_{\text{RESET}}|$ must be less than the specified limit in the [Section 6.4](#).
- D. V_{BIAS} should power up after V_{OFFSET} has powered up, per the Delay1 specification in [Table 9-2](#).
- E. DLP controller software initiates the global V_{BIAS} command.
- F. After the DMD micromirror park sequence is complete, the DLP controller software initiates a hardware power-down that activates DMD_EN_ARSTZ and disables V_{BIAS} , V_{RESET} and V_{OFFSET} .
- G. Under power-loss conditions where emergency DMD micromirror park procedures are being enacted by the DLP controller hardware DMD_EN_ARSTZ will go low.
- H. V_{DD} must remain high until after V_{OFFSET} , V_{BIAS} , V_{RESET} go low, per Delay2 specification in [Table 9-2](#).
- I. To prevent excess current, the supply voltage delta $|V_{\text{DDA}} - V_{\text{DD}}|$ must be less than specified limit in [Section 6.4](#).

Figure 9-1. DMD Power Supply Requirements

Table 9-2. DMD Power-Supply Requirements

| PARAMETER | DESCRIPTION | MIN | NOM | MAX | UNIT |
|-----------------------|--|-----|-----|-----|------|
| Delay1 ⁽¹⁾ | Delay from V_{OFFSET} settled at recommended operating voltage to V_{BIAS} and V_{RESET} power up | 1 | 2 | | ms |
| Delay2 ⁽¹⁾ | Delay V_{DD} must be held high from V_{OFFSET} , V_{BIAS} and V_{RESET} powering down. | 50 | | | us |

(1) See [Figure 9-1](#).

10 Layout

10.1 Layout Guidelines

The DLP471TP DMD is part of a chipset that is controlled by DLPC6540 display controller in conjunction with the [DLPA3005](#) PMIC and LED driver . These guidelines are targeted at designing a PCB board with the DLP471TP DMD. The DMD board is a high-speed multi-layer PCB, with primarily high-speed digital logic including double data rate 3.2 Gbps and 250 Mbps differential data buses run to the DMD. TI recommends that full or mini power planes are used for V_{OFFSET} , V_{RESET} , and V_{BIAS} . Solid planes are required for ground (V_{SS}). The target impedance for the PCB is $50\ \Omega \pm 10\%$ with exceptions listed in [Table 10-1](#). TI recommends a 10 layer stack-up as described in [Table 10-2](#). TI recommends manufacturing the PCB with a high quality FR-4 material.

10.2 Impedance Requirements

TI recommends a target impedance for the PCB of $50\ \Omega \pm 10\%$ for all signals. The exceptions are listed in [Table 10-1](#).

Table 10-1. Special Impedance Requirements

| Signal Type | Signal Name | Impedance (ohms) |
|---------------------------------|---|--|
| DMD High Speed Data Signals | DMD_HSSI0_N_(0...7), DMD_HSSI0_P_(0...7), DMD_HSSI1_N_(0...7), DMD_HSSI1_P_(0...7), DMD_HSSI0_CLK_N, DMD_HSSI0_CLK_P, DMD_HSSI1_CLK_N, DMD_HSSI1_CLK_P | 100 ohm differential (50 ohm single ended) |
| DMD Low Speed Interface Signals | DMD_LS0_WDATA_N, DMD_LS0_WDATA_P, DMD_LS0_CLK_N, DMD_LS0_CLK_P | 100 ohm differential (50 ohm single ended) |

10.3 Layers

The layer stack-up and copper weight for each layer is shown in [Table 10-2](#) .

Table 10-2. Layer Stack-Up

| LAYER NO. | LAYER NAME | COPPER WT. (oz.) | COMMENTS |
|-----------|---|-------------------------|---|
| 1 | Side A – DMD, Primary Components, Power mini-planes | 0.5 oz (before plating) | DMD and escapes. 2 data input connectors. Top components including power generation and 2 data input connectors. Low frequency signals routing. Want copper fill (GND) plated up to 1 oz. |
| 2 | Ground | 0.5 | Solid Ground Plane (net GND) Reference for signal layers #1, 3. |
| 3 | Signal (High frequency) | 0.5 | High Speed Signal layer. High Speed Differential Data Busses from input connector to DMD. |
| 4 | Ground | 0.5 | Solid Ground Plane (net GND) Reference for signal layers #3, #5. |
| 5 | Power | 0.5 | Primary Split Power Planes for 1.8V, 10V, -14V, 18V. |
| 6 | Power | 0.5 | Primary Split Power Planes for 1.8V, 10V, -14V, 18V. |
| 7 | Ground | 0.5 | Solid Ground Plane (net GND) Reference for signal layer #8 |
| 8 | Signal (High frequency) | 0.5 | High Speed Signal layer. High Speed Differential Data Busses from input connector to DMD. |
| 9 | Ground | 0.5 | Solid Ground Plane (net GND) Reference for signal layers #8, 10. |
| 10 | Side B –Secondary Components, Power mini-planes | 0.5 oz (before plating) | Discrete components if necessary. Low frequency signals routing. Want copper fill plated up to 1 oz. |

10.4 Trace Width, Spacing

Unless otherwise specified, TI recommends that all signals follow the 0.005"/0.015" (Trace-Width/Spacing) design rule. Actual trace widths and clearances should be determined and calculated based on an analysis of impedance and stack-up requirements.

The width of all voltage signals shall be maximized as space permits. In particular, the following width and spacing requirements shall be observed for the specific signals listed in [Table 10-3](#).

Table 10-3. Special Trace Widths, Spacing Requirements

| SIGNAL NAME | MINIMUM TRACE WIDTH (MIL) | MINIMUM TRACE SPACING (MIL) | LAYOUT REQUIREMENT |
|---------------------|---------------------------|-----------------------------|---|
| GND | MAXIMIZE | 5 | Maximize trace width to connecting pin as a minimum. |
| P1P8V | 100 | 15 | Create mini planes on layers 1 and 10 as needed. Connect to devices on layers 1 and 10 as necessary with multiple vias. |
| V _{OFFSET} | 40 | 15 | Create mini planes on layers 1 and 10 as needed. Connect to devices on layers 1 and 10 as necessary. |
| V _{RESET} | 40 | 15 | Create mini planes on layers 1 and 10 as needed. Connect to devices on layers 1 and 10 as necessary. |
| V _{BIAS} | 40 | 15 | Create mini planes on layers 1 and 10 as needed. Connect to devices on layers 1 and 10 as necessary. |

10.5 Power

TI strongly discourages signal routing on power planes or on planes adjacent to power planes. If signals must be routed on layers adjacent to power planes, they must not cross splits in power planes to prevent EMI and preserve signal integrity.

It is also desirable to have all internal digital ground (GND) planes connected together in as many places as possible. If possible, all internal ground planes should be connected together with a minimum distance between connections of 0.5". Extra vias may not be required if there are sufficient ground vias due to normal ground connections of devices.

Power and Ground pins of each component should be connected to the power and ground planes with at least one via for each pin. Trace lengths for component power and ground pins should be minimized (ideally, less than 0.100").

Ground plane slots are strongly discouraged.

10.6 Trace Length Matching Recommendations

Recommended signal trace length matching requirements can be found in [Table 10-4](#) and [Table 10-5](#). When length matching traces, the longer signals should be routed in a serpentine fashion, keeping the number of turns to a minimum and the turn angles no sharper than 45 degrees as opposed to running long traces over large areas of the PCB.

Signals in [Table 10-4](#) should be routed for data rate operation at up to 3.2 Gbps. Layer changes for these signals should be minimized, the number of vias should be minimized. Avoid sharp turns and layer switching while keeping lengths to a minimum. When layer changes are necessary, GND vias should be placed around the signal vias to provide a signal return path. The distance from one pair of differential signals to another shall be at least 2 times the distance within the pair.

Table 10-4. HSSI High Speed DMD Data Signals

| SIGNAL NAME | REFERENCE SIGNAL | Routing Spec | Unit |
|---|------------------------------------|--------------|------|
| DMD_HSSI0_N(0...7), DMD_HSSI0_P(0...7) | DMD_HSSI0_CLK_N, DMD_HSSI_CLK_P | +/- 0.25 | inch |
| DMD_HSSI1_N(0...7), DMD_HSSI1_P(0...7) | DMD_HSSI0_CLK_N, DMD_HSSI_CLK_P | +/- 0.25 | inch |
| DMD_HSSI0_CLK_P | DMD_HSSI1_CLK_P | +/- 0.05 | inch |
| Intra-pair P | Intra-pair N | +/- 0.01 | inch |

Table 10-5. Other Timing Critical Signals

| SIGNAL NAME | Constraints | Routing Layers |
|---|---|----------------|
| LS_CLK_P, LS_CLK_N LS_WDATA_P, LS_WDATA_N LS_RDATA_A | Intra-pair (P to N) Matched to 0.01 inches Signal-to-signal Matched to +/- 0.25 inches | Layers 3, 8 |

11 Device and Documentation Support

11.1 Device Support

11.1.1 Device Nomenclature

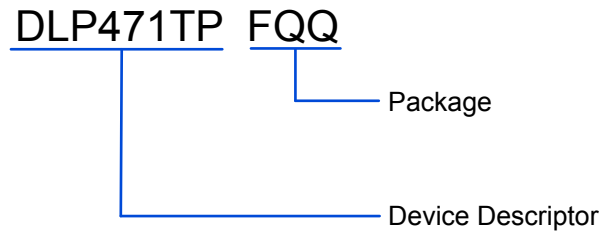


Figure 11-1. Part Number Description

11.1.2 Device Markings

The device marking includes both human-readable information and a 2-dimensional matrix code. The human-readable information is described in [Figure 11-2](#) and includes the legible character string GHJJJK DLP471TPFQQ. GHJJJK is the lot trace code and DLP471TPFQQ is the device marking.

Example: GHJJJK DLP471TPFQQ

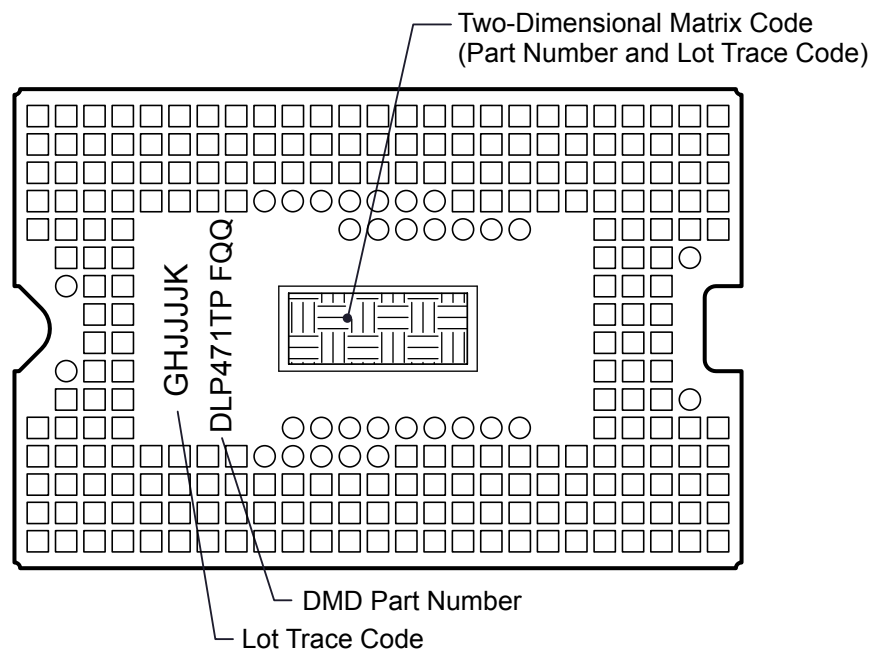


Figure 11-2. DMD Marking Locations

11.2 Documentation Support

11.2.1 Related Documentation

The following documents contain additional information related to the chipset components used with the DMD.

- [DLPC6540 Display Controller Data Sheet](#)
- [DLPA3005 PMIC/LED Driver Data Sheet](#)

11.3 Support Resources

[TI E2E™ support forums](#) are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

Linked content is provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's [Terms of Use](#).

11.4 Trademarks

Pico™ and TI E2E™ are trademarks of Texas Instruments.

DLP® is a registered trademark of Texas Instruments.

All other trademarks are the property of their respective owners.

11.5 Electrostatic Discharge Caution



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

12 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

12.1 Package Option Addendum

PACKAGING INFORMATION

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead finish/ Ball material (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|------------------|---------------|--------------|-----------------|------|-------------|-----------------|--------------------------------------|----------------------|--------------|-------------------------|---------|
| DLP471TPFQQ | ACTIVE | CLGA | FQQ | 270 | 54 | RoHS & Green | Call TI | N / A for Pkg Type | 0 to 70 | | Samples |
| XDLP471TPFQQ | ACTIVE | CLGA | FQQ | 270 | | TBD | Call TI | Call TI | 0 to 70 | | Samples |

(1) The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBSOLETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

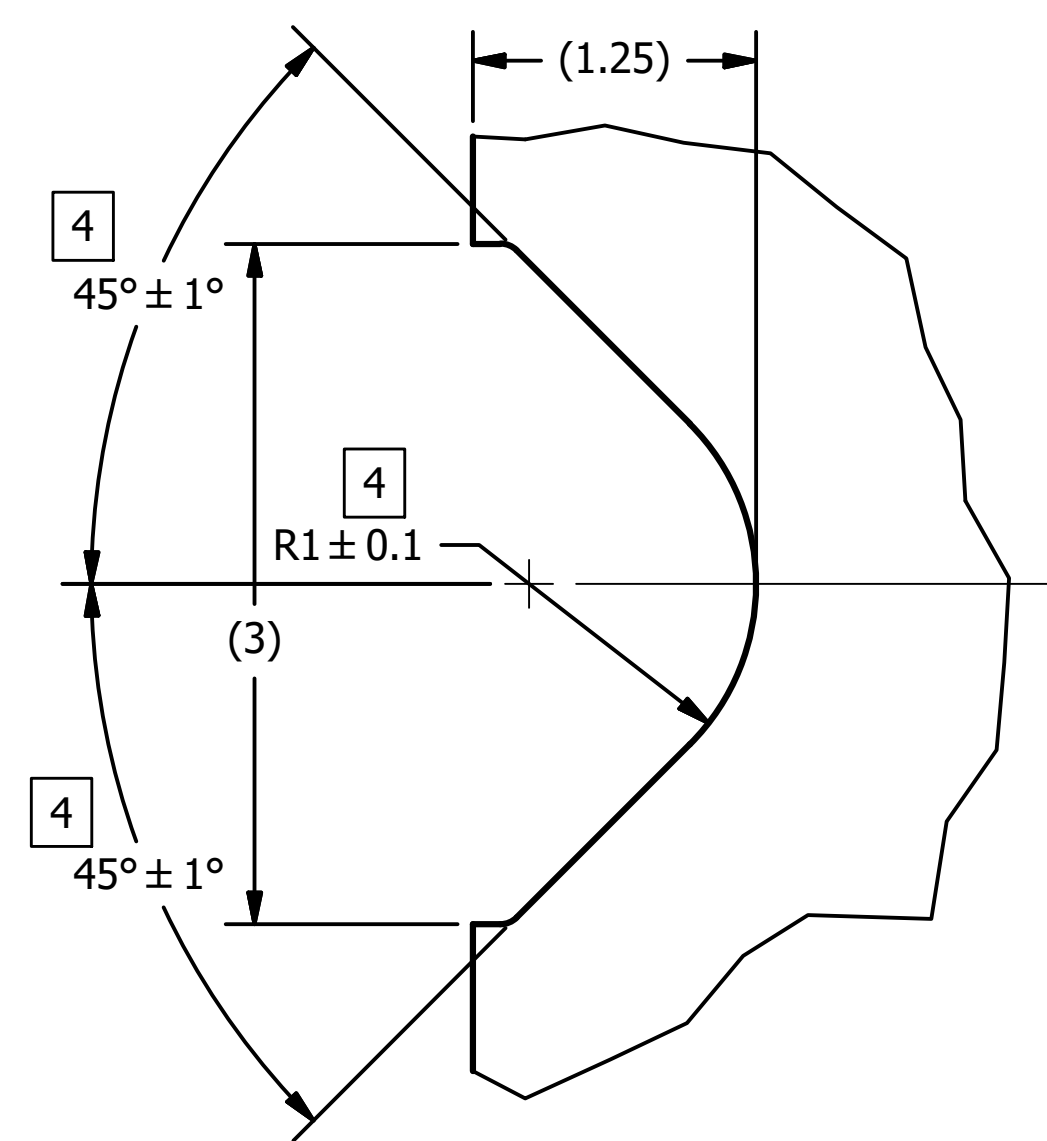
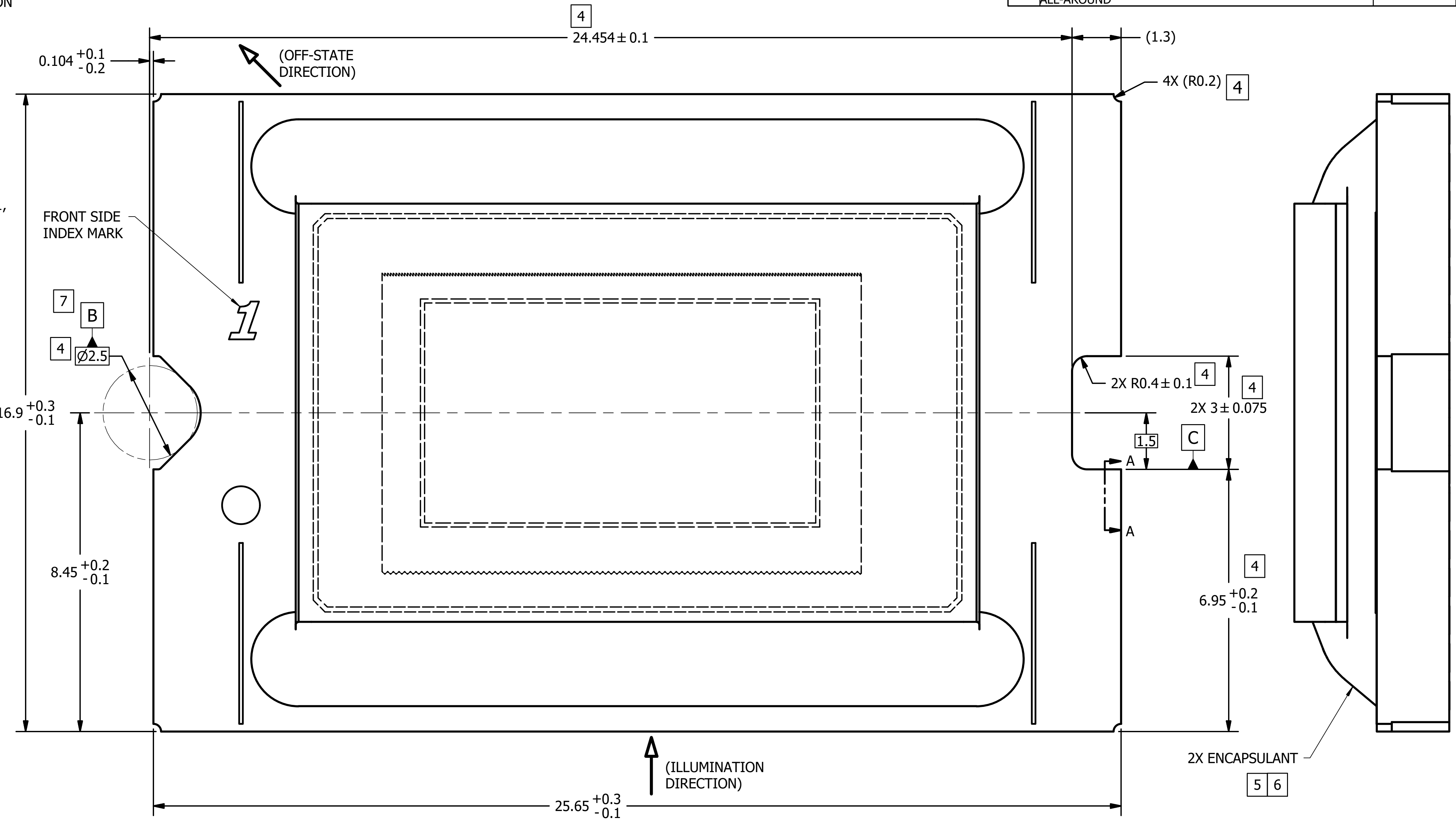
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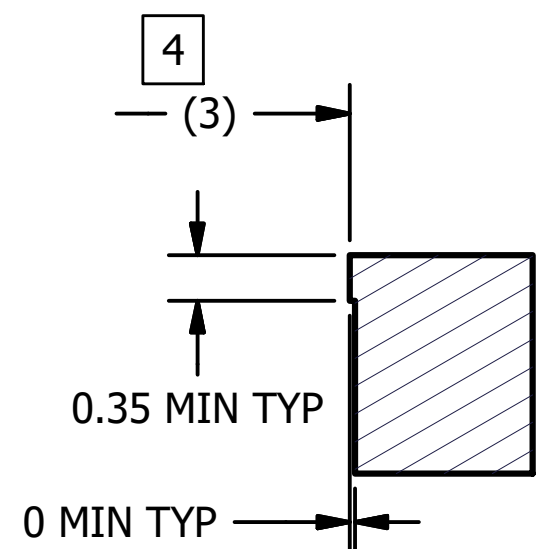
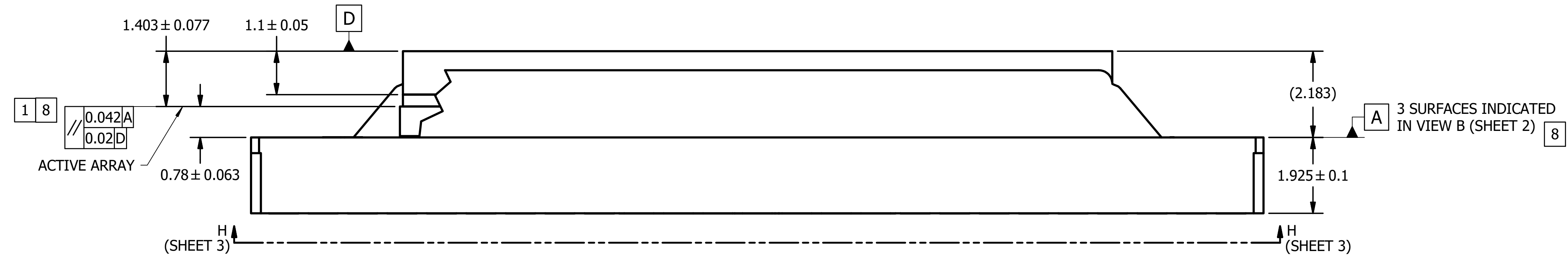
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| REVISIONS | | | |
|-----------|---|------------|-----|
| REV | DESCRIPTION | DATE | BY |
| A | ECO 2178176: INITIAL RELEASE | 12/11/2018 | BMH |
| B | ECO: 2187413: CHANGE SHORT APERTURE SLOTS TO ALL-AROUND | 4/29/2020 | PPC |

- NOTES UNLESS OTHERWISE SPECIFIED:
- 1 DIE PARALLELISM TOLERANCES APPLY TO DMD ACTIVE ARRAY ONLY.
 - 2 ROTATION ANGLE OF DMD ACTIVE ARRAY IS A REFINEMENT OF THE LOCATION TOLERANCE AND HAS A MAXIMUM ALLOWED VALUE OF 0.6 DEGREES.
 - 3 BOUNDARY MIRRORS SURROUNDING THE DMD ACTIVE ARRAY.
 - 4 NOTCH DIMENSIONS ARE DEFINED BY UPPERMOST LAYERS OF CERAMIC, AS SHOWN IN SECTION A-A.
 - 5 ENCAPSULANT TO BE CONTAINED WITHIN DIMENSIONS SHOWN IN VIEW D (SHEET 3). NO ENCAPSULANT IS ALLOWED ON TOP OF THE WINDOW.
 - 6 ENCAPSULANT NOT TO EXCEED THE HEIGHT OF THE WINDOW.
 - 7 SEE DETAIL B FOR "V-NOTCH" DIMENSIONS.
 - 8 WHILE ONLY THE THREE DATUM A TARGET AREAS A1, A2, AND A3 ARE USED FOR MEASUREMENT, ALL 4 CORNERS SHOULD BE CONTACTED, INCLUDING E1, TO SUPPORT MECHANICAL LOADS.



DETAIL B
V-NOTCH
SCALE 30 : 1



SECTION A-A
(ROTATED 90°)

| | | | | |
|---|---|--|---|----------|
| UNLESS OTHERWISE SPECIFIED • DIMENSIONS ARE IN MILLIMETERS • TOLERANCES: ANGLES ± 1° 2 PLACE DECIMALS ± 0.25 1 PLACE DECIMALS ± 0.50 • DIMENSIONAL LIMITS APPLY BEFORE PROCESSING • INTERPRET DIMENSIONS IN ACCORDANCE WITH ASME Y14.5M-1994 • REMOVE ALL BURRS AND SHARP EDGES • PARENTHETICAL INFORMATION FOR REFERENCE ONLY | DRAWN B. HASKETT 12/11/2018 ENGINEER B. HASKETT 12/11/2018 QA/CE K. DICKERSON 12/12/2018 CM B. HASKETT 12/19/2018 APPROVED J. MCKINLEY 12/18/2018 HERMOSILLO 12/18/2018 | DATE 12/11/2018 12/11/2018 12/12/2018 12/19/2018 12/18/2018 12/18/2018 | TITLE ICD, MECHANICAL, DMD, .47 4K HSSI SERIES 317 (FQQ PACKAGE) | |
| | APPLICATION 0314DA NEXT ASSY USED ON | SIZE D | DWG NO. 2516402 | REV B |
| | SCALE 15:1 | SHEET 1 OF 5 | | |
| | | | | |

D

D

C

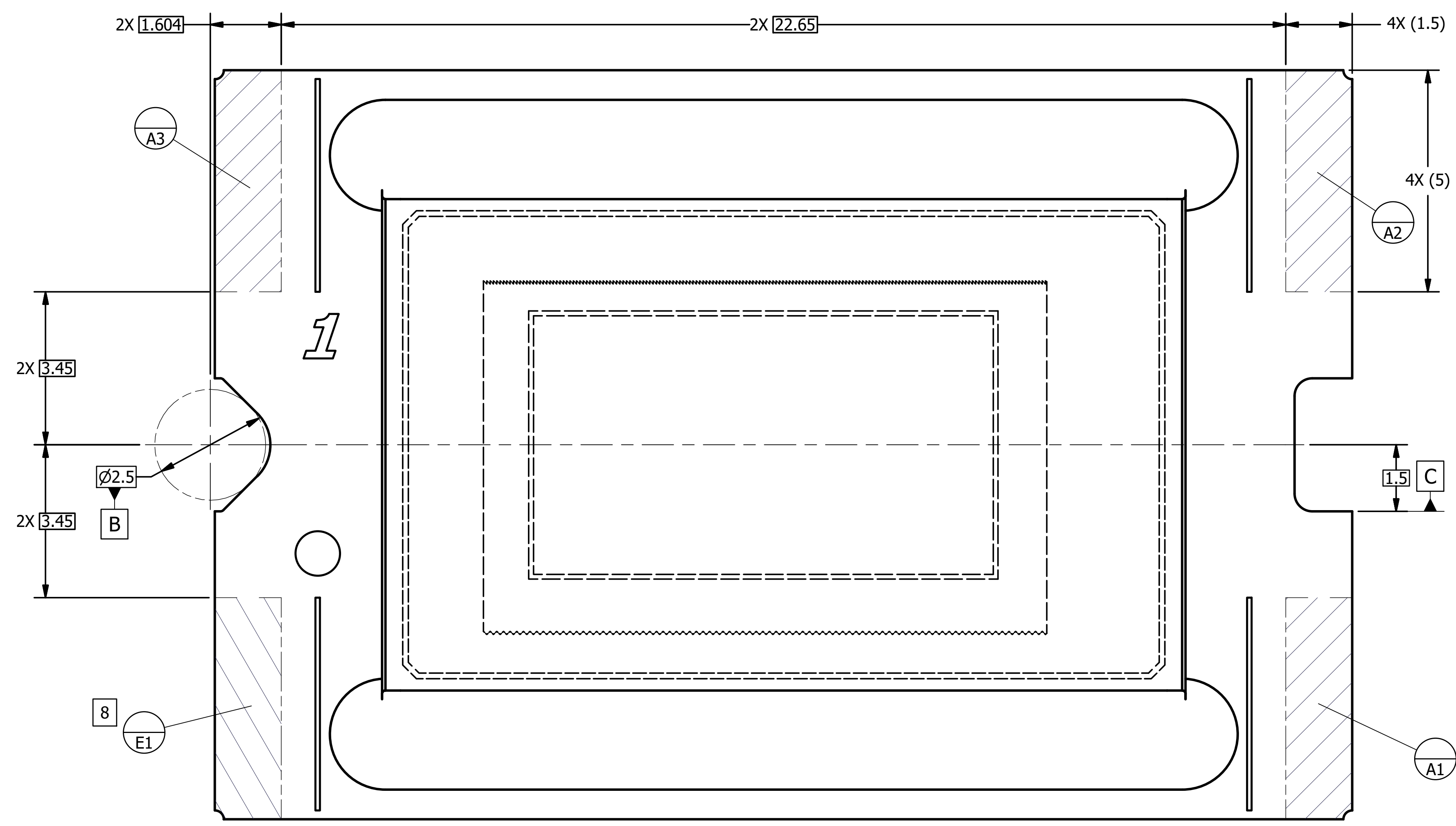
C

B

B

A

A



VIEW C
 DATUMS A AND E
 (FROM SHEET 1)

D

D

C

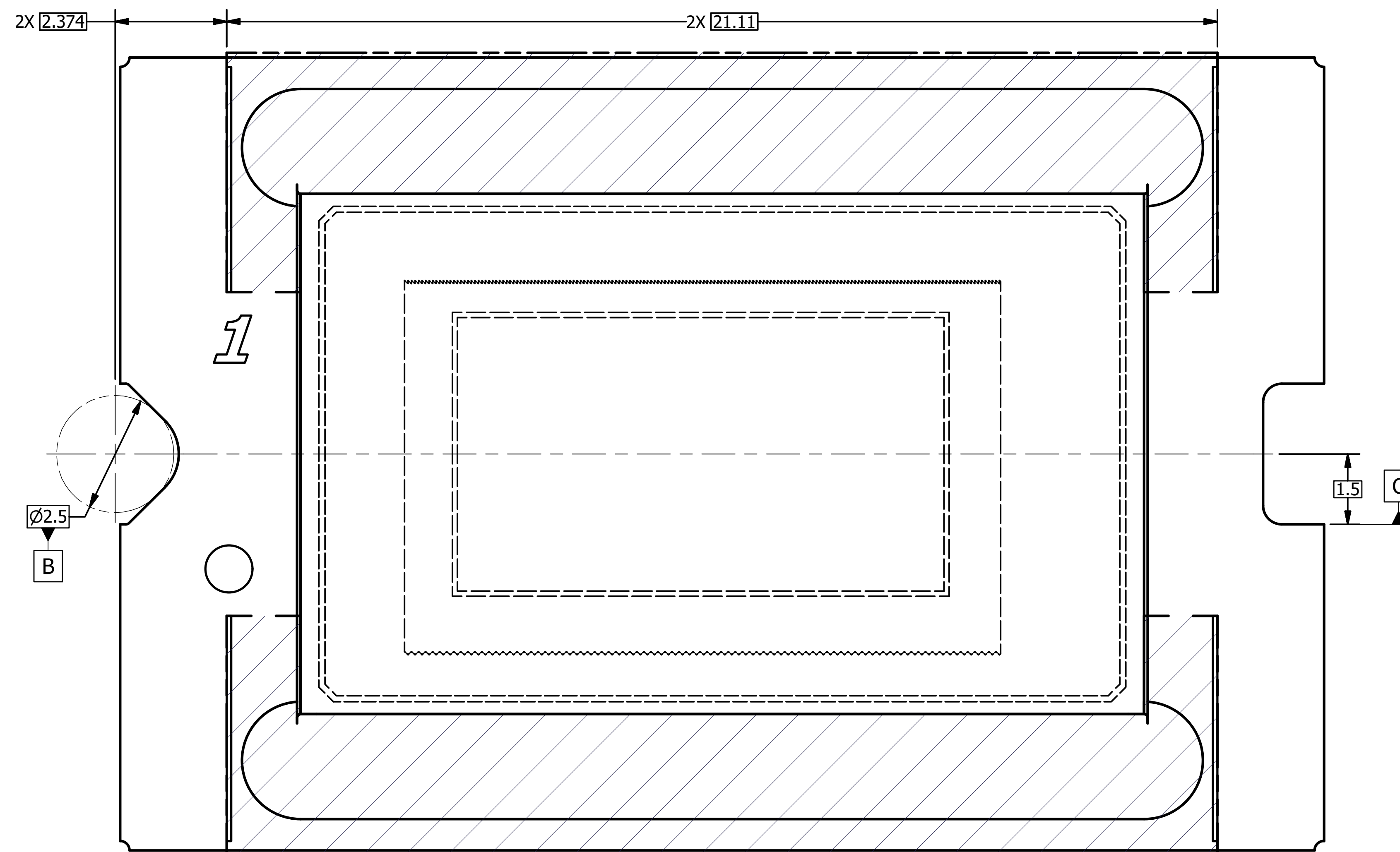
C

B

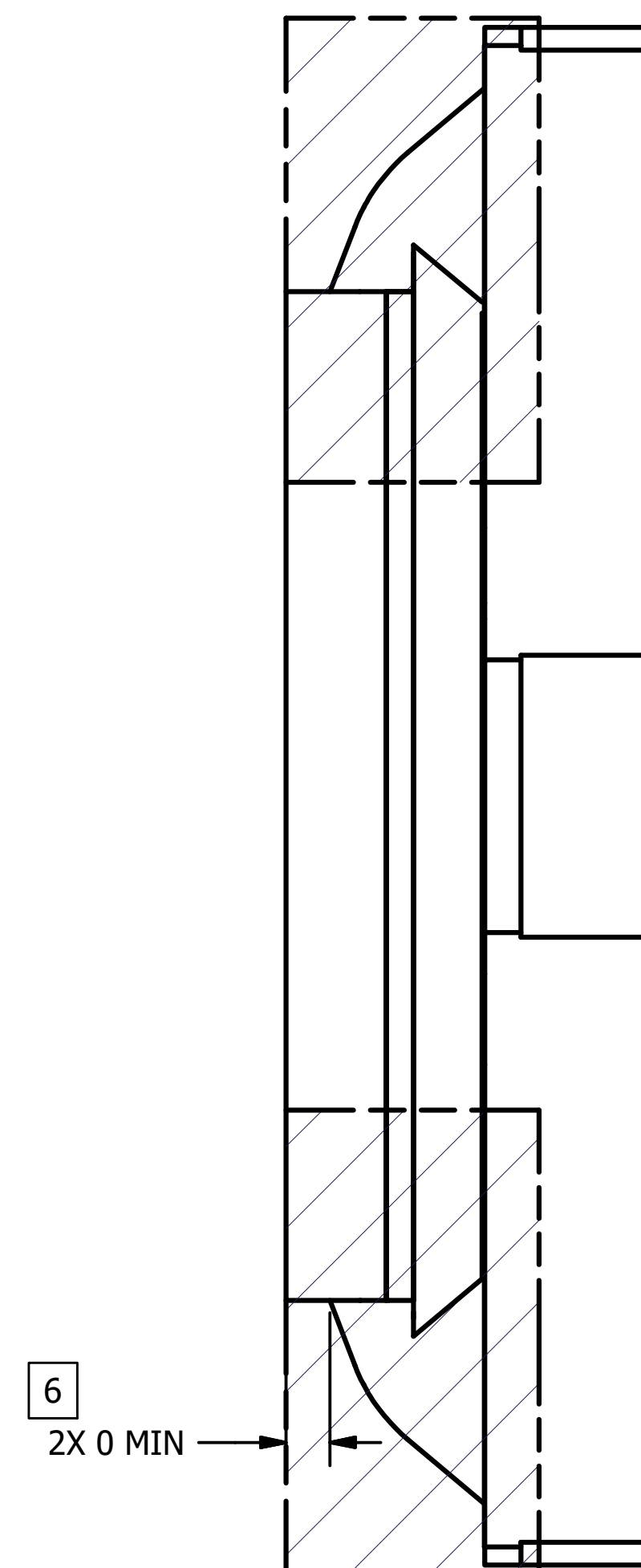
B

A

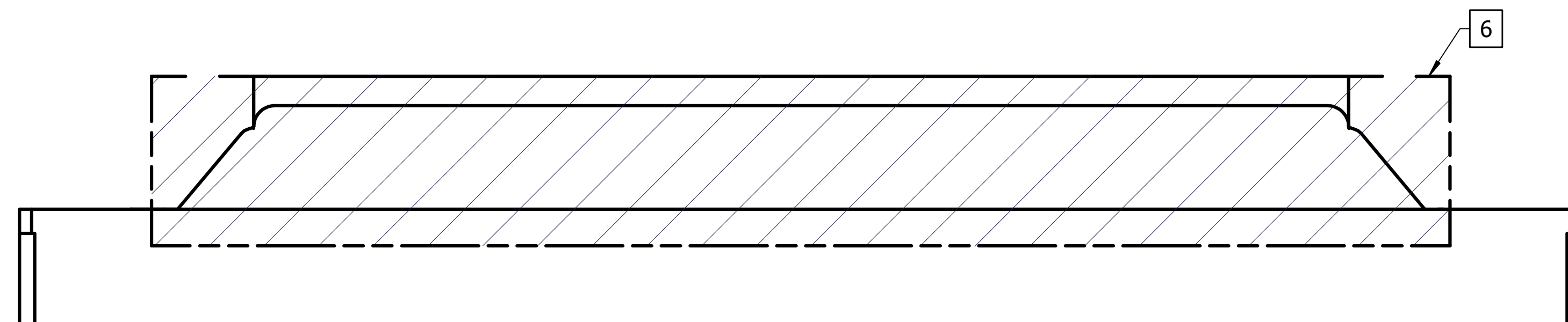
A



VIEW D
ENCAPSULANT MAXIMUM X/Y DIMENSIONS [5]
(FROM SHEET 1)



VIEW E
MAXIMUM ENCAPSULANT HEIGHT



D

D

C

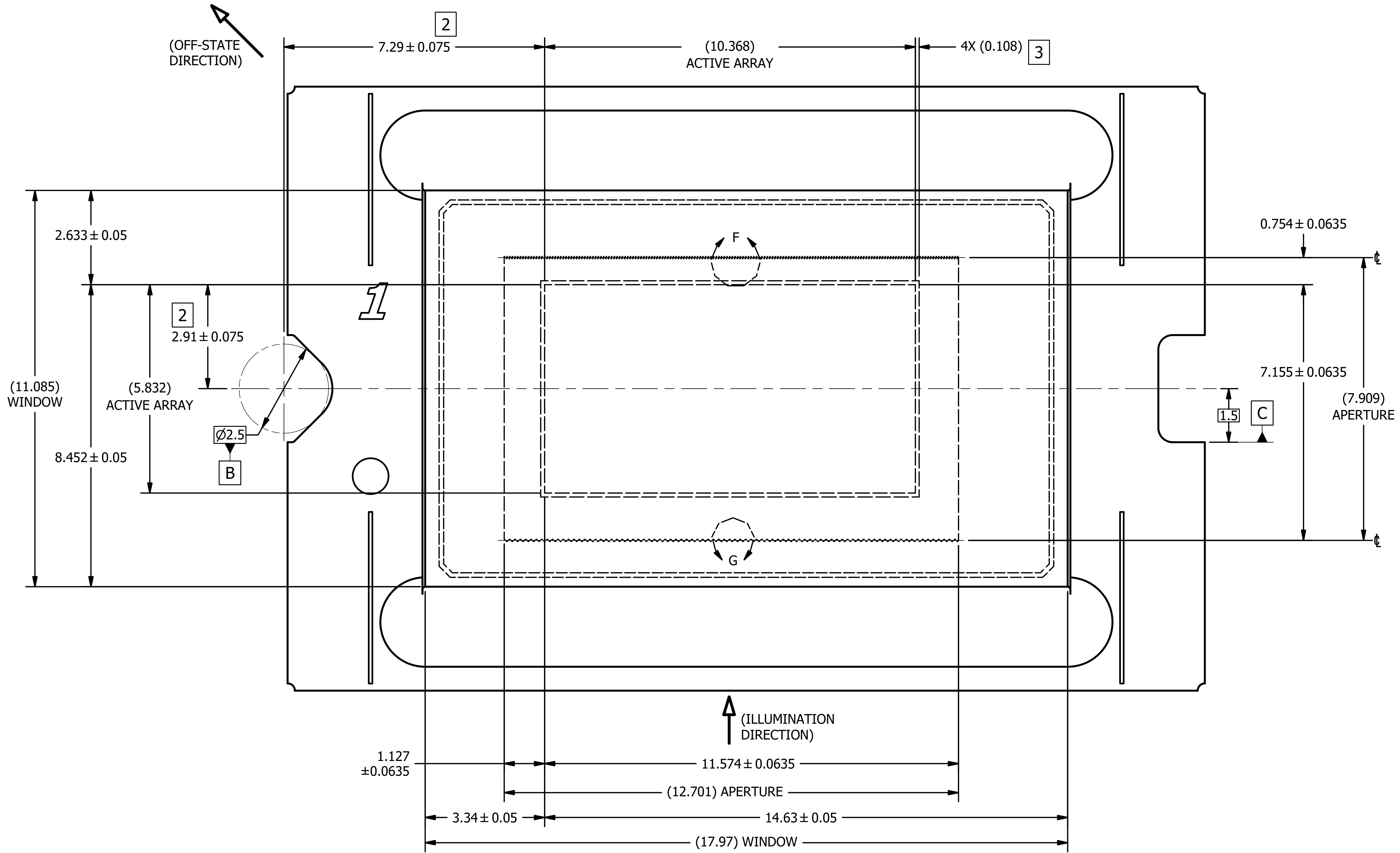
C

B

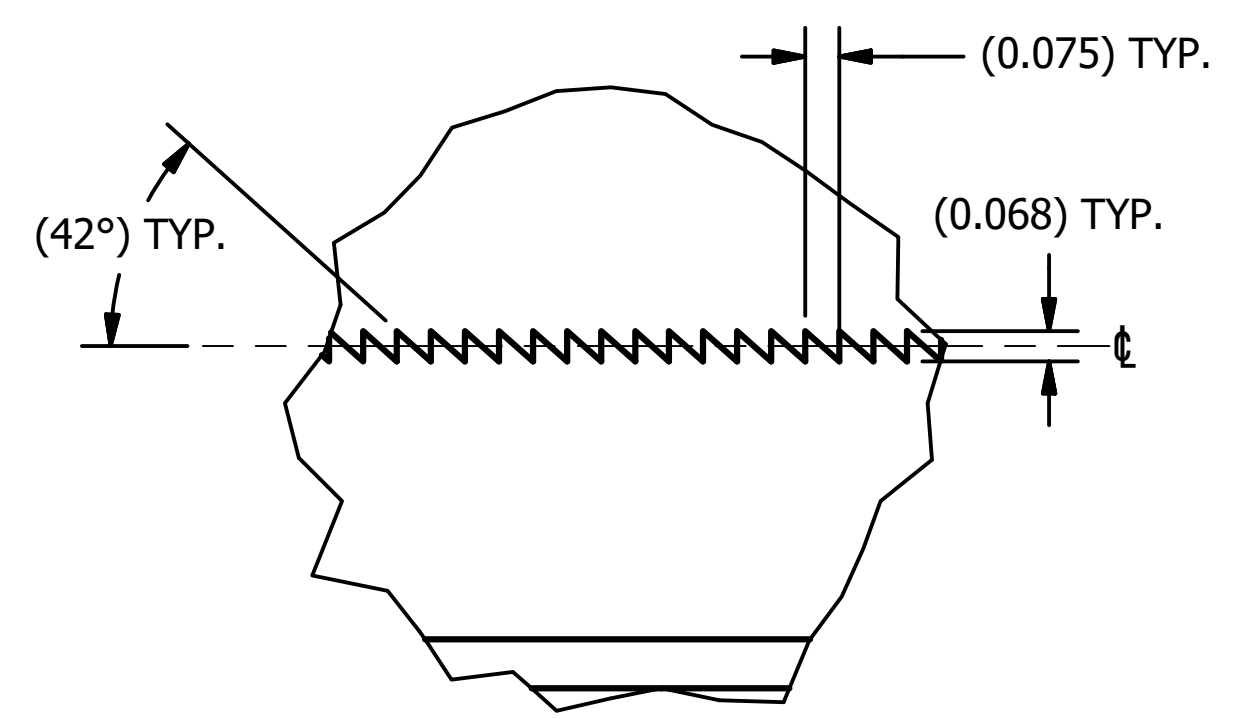
B

A

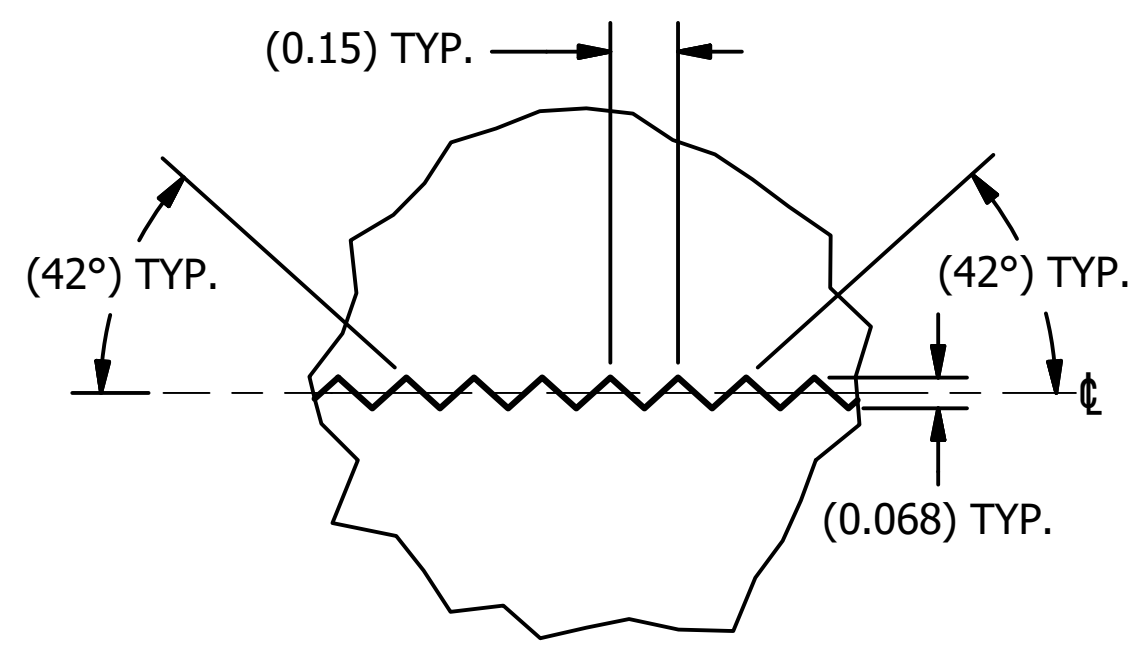
A



VIEW E
WINDOW AND ACTIVE ARRAY
 (FROM SHEET 1)



DETAIL F
APERTURE TOP EDGE
 (GLASS OMITTED FOR CLARITY)
 SCALE 60 : 1



DETAIL G
APERTURE BOTTOM EDGE
 (GLASS OMITTED FOR CLARITY)
 SCALE 60 : 1

D

D

C

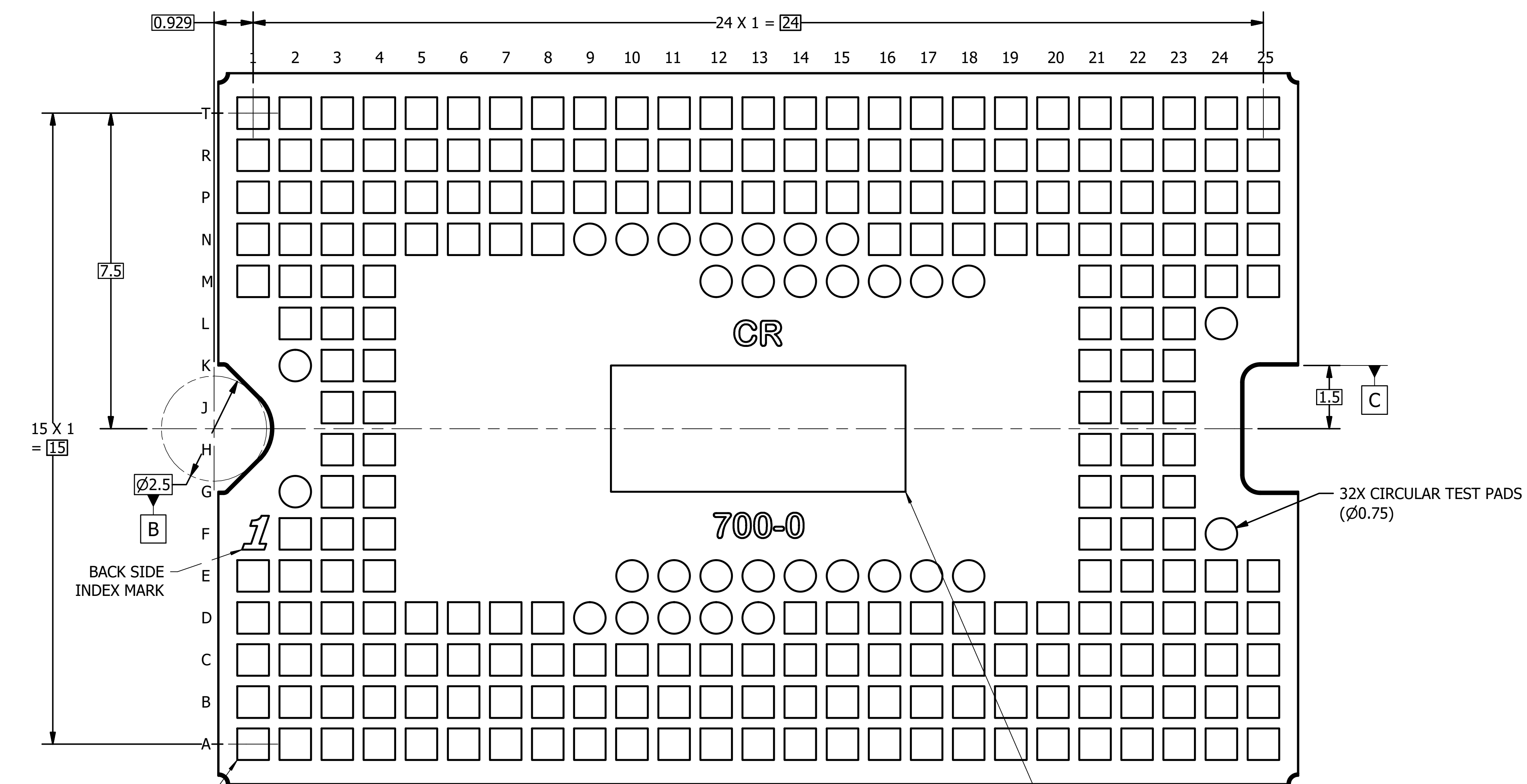
C

B

B

A

A



238X SQUARE LGA PADS
 0.75±0.05 X 0.75±0.05

| | |
|---|-----------|
| Ø | 0.2 A B C |
| Ø | 0.1 A |

VIEW H-H
 BACK SIDE METALIZATION
 (FROM SHEET 1)

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