

DLP650NE 0.65-Inch 1080p Digital Micromirror Device

1 Features

- 0.65-inch micromirror array diagonal
 - 1080p (1920 × 1080)
 - 7.56-micron micromirror pitch
 - ± 12° micromirror tilt angle (relative to flat state)
 - Corner illumination
- 2xLVDS input data bus
- The DLP650NE chipset includes:
 - [DLP650NE DMD](#)
 - [DLPC4420 controller](#)
 - [DLPA100 controller power management and motor driver IC](#)

2 Applications

- [Full HD \(1080p\) display](#)
- [Laser TV](#)
- [Mobile smart TV](#)
- [Digital signage](#)
- [Gaming](#)
- [Home cinema](#)

3 Description

The TI DLP650NE [digital micromirror device \(DMD\)](#) is a digitally controlled micro-electromechanical system (MEMS) spatial light modulator (SLM) that enables bright, affordable DLP® 0.65-inch 1080p display solutions. The DLP650NE DMD—together with the DLPC4420 display controller and the DLPA100 power manager and motor driver—provides the capability to achieve high-performance systems, and is a great fit for display applications that require high resolution and 16:9 aspect ratio, high brightness, and system simplicity. The DLP650NE DMD can also utilize the DLPC4430 as a display controller.

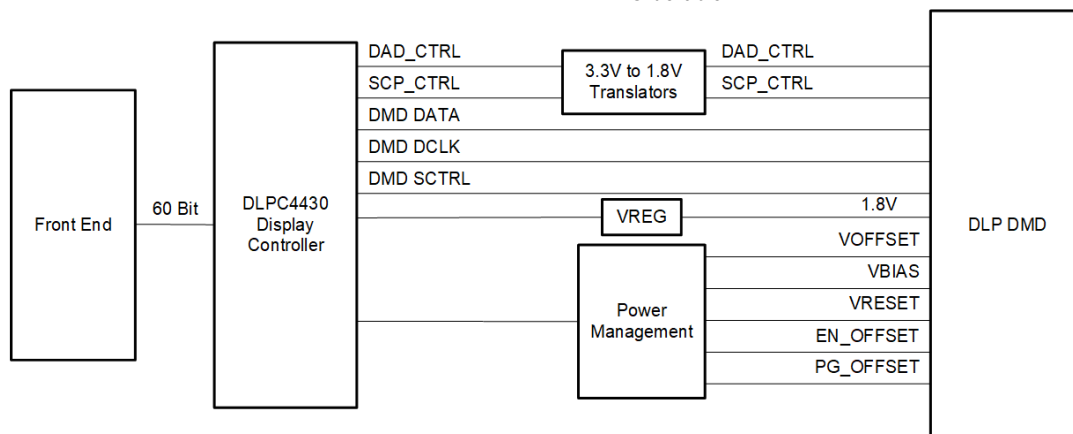
The DMD ecosystem includes established resources to help the user accelerate the design cycle, visit the [DLP® Products third-party search tools](#) to find approved optical module manufacturers and third party providers.

Visit [Getting Started With TI DLP Display Technology](#) to learn more about how to start designing with the DMD.

Device Information

PART NUMBER	PACKAGE ⁽¹⁾	PACKAGE SIZE
DLP650NE	FYE (350)	35.0mm × 32.2mm × 5.1mm

(1) For more information, see the *Mechanical, Packaging, and Orderable* addendum.



DLP650NE Simplified Application



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4 Pin Configuration and Functions

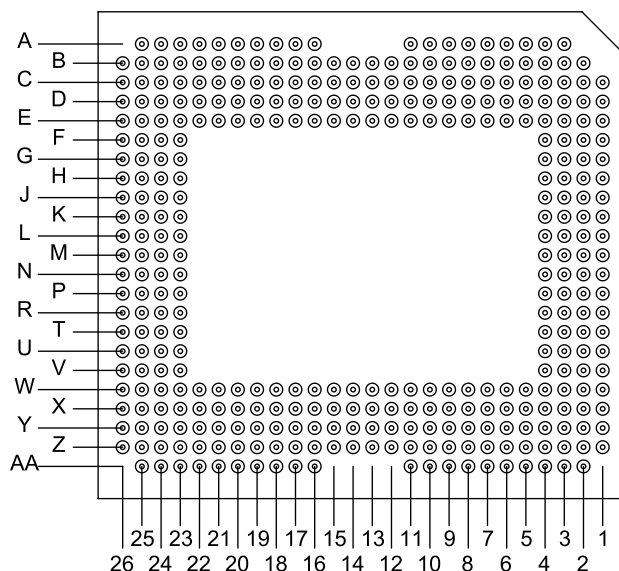


Figure 4-1. FYE Package 350-Pin Bottom View

Table 4-1. Pin Functions

PIN ⁽¹⁾		TYPE ⁽⁵⁾	SIGNAL	DATA RATE ⁽²⁾	INTERNAL TERM ⁽³⁾	DESCRIPTION	TRACE (mils) ⁽⁴⁾
NAME	NO.						
DATA BUS A							
D_AN(0)	B14	I	LVDS	DDR	Differential	Data, negative	494.88
D_AN(1)	B15	I		DDR	Differential	Data, negative	486.18
D_AN(2)	C16	I		DDR	Differential	Data, negative	495.16
D_AN(3)	K24	I		DDR	Differential	Data, negative	485.67
D_AN(4)	B18	I		DDR	Differential	Data, negative	494.76
D_AN(5)	L24	I		DDR	Differential	Data, negative	490.63
D_AN(6)	C19	I		DDR	Differential	Data, negative	495.16
D_AN(7)	H24	I		DDR	Differential	Data, negative	485.55
D_AN(8)	H23	I		DDR	Differential	Data, negative	495.16
D_AN(9)	B25	I		DDR	Differential	Data, negative	485.59
D_AN(10)	D24	I		DDR	Differential	Data, negative	495.16
D_AN(11)	E25	I		DDR	Differential	Data, negative	495.16
D_AN(12)	F25	I		DDR	Differential	Data, negative	490.04
D_AN(13)	H25	I		DDR	Differential	Data, negative	485.91
D_AN(14)	L25	I		DDR	Differential	Data, negative	495.16
D_AN(15)	G24	I		DDR	Differential	Data, negative	495.16

Table 4-1. Pin Functions (continued)

PIN ⁽¹⁾		TYPE ⁽⁵⁾	SIGNAL	DATA RATE ⁽²⁾	INTERNAL TERM ⁽³⁾	DESCRIPTION	TRACE (mils) ⁽⁴⁾
NAME	NO.						
D_AP(0)	C14	I	LVDS	DDR	Differential	Data, positive	494.84
D_AP(1)	B16	I		DDR	Differential	Data, positive	486.22
D_AP(2)	C17	I		DDR	Differential	Data, positive	494.65
D_AP(3)	K23	I		DDR	Differential	Data, positive	488.42
D_AP(4)	B19	I		DDR	Differential	Data, positive	495.16
D_AP(5)	L23	I		DDR	Differential	Data, positive	490.67
D_AP(6)	C20	I		DDR	Differential	Data, positive	498.11
D_AP(7)	J24	I		DDR	Differential	Data, positive	486.22
D_AP(8)	J23	I		DDR	Differential	Data, positive	495.47
D_AP(9)	C25	I		DDR	Differential	Data, positive	485.94
D_AP(10)	E24	I		DDR	Differential	Data, positive	495.16
D_AP(11)	D25	I		DDR	Differential	Data, positive	494.13
D_AP(12)	G25	I		DDR	Differential	Data, positive	488.98
D_AP(13)	J25	I		DDR	Differential	Data, positive	492.56
D_AP(14)	K25	I		DDR	Differential	Data, positive	495.16
D_AP(15)	F24	I		DDR	Differential	Data, positive	495.16
DATA BUS B							
D_BN(0)	Z14	I	LVDS	DDR	Differential	Data, negative	494.92
D_BN(1)	Z15	I		DDR	Differential	Data, negative	486.18
D_BN(2)	Y16	I		DDR	Differential	Data, negative	496.46
D_BN(3)	P24	I		DDR	Differential	Data, negative	493.74
D_BN(4)	Z18	I		DDR	Differential	Data, negative	494.76
D_BN(5)	N24	I		DDR	Differential	Data, negative	495.16
D_BN(6)	Y19	I		DDR	Differential	Data, negative	492.16
D_BN(7)	T24	I		DDR	Differential	Data, negative	492.68
D_BN(8)	T23	I		DDR	Differential	Data, negative	484.45
D_BN(9)	Z25	I		DDR	Differential	Data, negative	492.09
D_BN(10)	X24	I		DDR	Differential	Data, negative	497.72
D_BN(11)	W25	I		DDR	Differential	Data, negative	495.16
D_BN(12)	V25	I		DDR	Differential	Data, negative	484.17
D_BN(13)	T25	I		DDR	Differential	Data, negative	481.42
D_BN(14)	N25	I		DDR	Differential	Data, negative	495.16
D_BN(15)	U24	I		DDR	Differential	Data, negative	489.8

Table 4-1. Pin Functions (continued)

PIN ⁽¹⁾		TYPE ⁽⁵⁾	SIGNAL	DATA RATE ⁽²⁾	INTERNAL TERM ⁽³⁾	DESCRIPTION	TRACE (mils) ⁽⁴⁾
NAME	NO.						
D_BP(0)	Y14	I	LVDS	DDR	Differential	Data, positive	494.88
D_BP(1)	Z16	I		DDR	Differential	Data, positive	486.26
D_BP(2)	Y17	I		DDR	Differential	Data, positive	495.16
D_BP(3)	P23	I		DDR	Differential	Data, positive	492.48
D_BP(4)	Z19	I		DDR	Differential	Data, positive	495.16
D_BP(5)	N23	I		DDR	Differential	Data, positive	497.99
D_BP(6)	Y20	I		DDR	Differential	Data, positive	495.16
D_BP(7)	R24	I		DDR	Differential	Data, positive	492.05
D_BP(8)	R23	I		DDR	Differential	Data, positive	484.45
D_BP(9)	Y25	I		DDR	Differential	Data, positive	492.24
D_BP(10)	W24	I		DDR	Differential	Data, positive	495.16
D_BP(11)	X25	I		DDR	Differential	Data, positive	494.72
D_BP(12)	U25	I		DDR	Differential	Data, positive	483.78
D_BP(13)	R25	I		DDR	Differential	Data, positive	489.13
D_BP(14)	P25	I		DDR	Differential	Data, positive	499.53
D_BP(15)	V24	I		DDR	Differential	Data, positive	488.66
SERIAL CONTROL							
SCTRL_AN	C23	I	LVDS	DDR	Differential	Serial control, negative	492.95
SCTRL_BN	Y23	I		DDR	Differential	Serial control, negative	493.78
SCTRL_AP	C24	I		DDR	Differential	Serial control, negative	493.78
SCTRL_BP	Y24	I		DDR	Differential	Serial control, negative	493.11
CLOCKS							
DCLK_AN	B23	I	LVDS		Differential	Clock, negative	480.35
DCLK_BN	Z23	I			Differential	Clock, negative	486.22
DCLK_AP	B22	I			Differential	Clock, negative	485.83
DCLK_BP	Z22	I			Differential	Clock, negative	491.93
SERIAL COMMUNICATIONS PORT (SCP)							
SCP_DO	B8	O	LVCMOS	SDR	Pulldown	Serial communications port output	
SCP_DI	B7	I		SDR		Serial communication port data I	
SCP_CLK	B6	I				Serial communications port clock	
SCP_ENZ	C8	I				Active-low serial communications port enable	

Table 4-1. Pin Functions (continued)

PIN ⁽¹⁾		TYPE ⁽⁵⁾	SIGNAL	DATA RATE ⁽²⁾	INTERNAL TERM ⁽³⁾	DESCRIPTION	TRACE (mils) ⁽⁴⁾
NAME	NO.						
MICROMIRROR RESET CONTROL							
RESET_ADDR(0)	X9	I	LVCMOS		Pulldown	Reset driver address select	
RESET_ADDR(1)	X8	I				Reset driver address select	
RESET_ADDR(2)	Z8	I				Reset driver address select	
RESET_ADDR(3)	Z7	I				Reset driver address select	
RESET_MODE(0)	W11	I				Reset driver mode select	
RESET_MODE(1)	Z10	I				Reset driver mode select	
RESET_SEL(0)	Y10	I				Reset driver level select	
RESET_SEL(1)	Y9	I				Reset driver level select	
RESET_STROBE	Y7	I				Reset address, mode, and level latched on rising-edge	
ENABLES AND INTERRUPTS							
PWRDNZ	D2	I	LVCMOS		Pulldown	Active-low device reset	
RESET_OEZ	W7	I			Pulldown	Active-low output enable for DMD reset driver circuits	
RESETZ	Z6	I			Pulldown	Active-low sets reset circuits in known VOFFSET state	
RESET_IRQZ	Z5	O				Active-low, output interrupt to ASIC	
VOLTAGE REGULATOR MONITORING							
PG_BIAS	E11	I	LVCMOS		Pullup	Active-low fault from external VBIAS regulator	
PG_OFFSET	B10	I				Active-low fault from external VOFFSET regulator	
PG_RESET	D11	I				Active low from external VRESET regulator	
EN_BIAS	D9	O				Active-high enable for external VBIAS regulator	
EN_OFFSET	C9	O				Active-high enable for external VOFFSET regulator	
EN_RESET	E9	O				Active-high enable for external VRESET regulator	

Table 4-1. Pin Functions (continued)

PIN ⁽¹⁾		TYPE ⁽⁵⁾	SIGNAL	DATA RATE ⁽²⁾	INTERNAL TERM ⁽³⁾	DESCRIPTION	TRACE (mils) ⁽⁴⁾	
NAME	NO.							
LEAVE PIN UNCONNECTED								
MBRST(0)	C2	O	Analog		Pulldown	For proper DMD operation, do not connect.		
MBRST(1)	C3	O						
MBRST(2)	C5	O						
MBRST(3)	C4	O						
MBRST(4)	E5	O						
MBRST(5)	E4	O						
MBRST(6)	E3	O						
MBRST(7)	G4	O						
MBRST(8)	G3	O						
MBRST(9)	G2	O						
MBRST(10)	J4	O						
MBRST(11)	J3	O						
MBRST(12)	J2	O						
MBRST(13)	L4	O						
MBRST(14)	L3	O						
MBRST(15)	L2	O						
LEAVE PIN UNCONNECTED								
RESERVED_PFE	E7	I	LVCMOS		Pulldown	For proper DMD operation, do not connect.		
RESERVED_TM	D13	I						
RESERVED_XI1	E13	I						
RESERVED_TP0	W12	I	Analog					
RESERVED_TP1	Y11	I						
RESERVED_TP2	X11	I						
LEAVE PIN UNCONNECTED								
RESERVED_BA	Y12	O	LVCMOS			For proper DMD operation, do not connect.		
RESERVED_BB	C12	O						
RESERVED_TS	D5	O						
LEAVE PIN UNCONNECTED								
NO CONNECT	B11					For proper DMD operation, do not connect.		
NO CONNECT	C11							
NO CONNECT	C13							
NO CONNECT	E12							
NO CONNECT	E14							
NO CONNECT	E23							
NO CONNECT	H4					For proper DMD operation, do not connect.		
NO CONNECT	N2							
NO CONNECT	N3							
NO CONNECT	N4							
NO CONNECT	R2							
NO CONNECT	R3							
NO CONNECT	R4							
NO CONNECT	T4							

Table 4-1. Pin Functions (continued)

PIN ⁽¹⁾		TYPE ⁽⁵⁾	SIGNAL	DATA RATE ⁽²⁾	INTERNAL TERM ⁽³⁾	DESCRIPTION	TRACE (mils) ⁽⁴⁾
NAME	NO.						
NO CONNECT	U2					For proper DMD operation, do not connect.	
NO CONNECT	U3						
NO CONNECT	U4						
NO CONNECT	W3						
NO CONNECT	W4						
NO CONNECT	W5						
NO CONNECT	W13						
NO CONNECT	W14						
NO CONNECT	W23					For proper DMD operation, do not connect.	
NO CONNECT	X4						
NO CONNECT	X5						
NO CONNECT	X13						
NO CONNECT	Y2						
NO CONNECT	Y3						
NO CONNECT	Y4						
NO CONNECT	Y5						
NO CONNECT	Z11						

(1) The following power supplies are required to operate the DMD: VCC, VCCI, VOFFSET, VBIAS, and VRESET. VSS must also be connected.

(2) DDR = Double Data Rate. SDR = Single Data Rate. Refer to [Section 5.7](#) for specifications and relationships.

(3) Internal term—CMOS level internal termination. Refer to [Section 5.4](#) for differential termination specification.

(4) Dielectric Constant for the DMD FYE package is approximately 9.6. For the package trace lengths shown: Propagation Speed = 11.8 / sqrt(9.6) = 3.808in/ns. Propagation Delay = 0.262ns/in = 262ps/in = 10.315ps/mm.

(5) I = Input, O = Output, G = Ground

Table 4-2. Power Pin Functions

PIN		TYPE (I/O/P) ⁽²⁾	SIGNAL	DESCRIPTION
NAME ⁽¹⁾	NO.			
VBIAS	A6, A7, A8, AA6, AA7, AA8	P	Analog	Supply voltage for positive Bias level of micromirror reset signal
VOFFSET	A3, A4, A25		Analog	Supply voltage for HVCMOS logic
	B26, L26, M26		Analog	Supply voltage for stepped high voltage at micromirror address electrodes
	N26, Z26, AA3, AA4		Analog	Supply voltage for positive Offset level of micromirror reset signal
VRESET	G1, H1, J1, R1, T1, U1		Analog	Supply voltage for negative Reset level of micromirror reset signal
VCC	A9, B3, B5, B12, C1, C6, C10, D4, D6, D8, E1, E2, E10, E15, E16, E17, F3, H2, K1, K3, M4, P1, P3, T2, V3, W1, W2, W6, W9, W10, W15, W16, W17, X3, X6, Y1, Y8, Y13, Z1, Z3, Z12, AA2, AA9, AA10		Analog	Supply voltage for LVCMOS core logic. Supply voltage for normal high level at micromirror address electrodes. Supply voltage for positive Offset level of micromirror reset signal during power-down sequence
VCCI	A16, A17, A18, A20, A21, A23, AA16, AA17, AA18, AA20, AA21, AA23		Analog	Supply voltage for LVDS receivers
VSS	A5, A10, A11, A19, A22, A24, B2, B4, B9, B13, B17, B20, B21, B24, C7, C15, C18, C21, C22, C26, D1, D3, D7, D10, D12, D14, D15, D16, D17, D18, D19, D20, D21, D22, D23, D26, E6, E8, E18, E19, E20, E21, E22, E26, F1, F2, F4, F23, F26, G23, G26, H3, H26, J26, K2, K4, K26, L1, M1, M2, M3, M23, M24, M25, N1, P2, P4, P26, R26, T3, T26, U23, U26, V1, V2, V4, V23, V26, W8, W18, W19, W20, W21, W22, W26, X1, X2, X7, X10, X12, X14, X15, X16, X17, X18, X19, X20, X21, X22, X23, X26, Y6, Y15, Y18, Y21, Y22, Y26, Z2, Z4, Z9, Z13, Z17, Z20, Z21, Z24, AA5, AA11, AA19, AA22, AA24		Analog	Device ground. Common return for all power

(1) The following power supplies are required to operate the DMD: VCC, VCCI, VOFFSET, VBIAS, and VRESET. VSS must also be connected.

(2) P = Power

5 Specifications

5.1 Absolute Maximum Ratings

Over operating free-air temperature range (unless otherwise noted). Operation outside the Absolute Maximum Ratings may cause permanent device damage. Absolute Maximum Ratings do not imply functional operation of the device at these or any other conditions beyond those listed under Recommended Operating Conditions. If outside the Recommended Operating Conditions but within the Absolute Maximum Ratings, the device may not be fully functional, and this may affect device reliability, functionality, performance, and shorten the device lifetime.

		MIN	MAX	UNIT
SUPPLY VOLTAGES				
VCC	Supply voltage for LVCMOS core logic ⁽¹⁾	–0.5	4	V
VCCI	Supply voltage for LVDS receivers ⁽¹⁾	–0.5	4	V
VOFFSET	Supply voltage for HVCMOS and micromirror electrode ^{(1) (2)}	–0.5	9	V
VBIAS	Supply voltage for micromirror electrode ⁽¹⁾	–0.5	17	V
VRESET	Supply voltage for micromirror electrode ⁽¹⁾	–11	0.5	V
VCC – VCCI	Supply voltage change (absolute value) ⁽³⁾		0.3	V
VBIAS – VOFFSET	Supply voltage change (absolute value) ⁽⁴⁾		8.75	V
INPUT VOLTAGES				
	Input voltage for all other LVCMOS input pins ⁽¹⁾	–0.5	VCC + 0.15	V
	Input voltage for all other LVDS input pins ^{(1) (5)}	–0.5	VCCI + 0.15	V
V _{ID}	Input differential voltage (absolute value) ⁽⁶⁾		700	mV
I _{ID}	Input differential current ⁽⁶⁾		7	mA
CLOCKS				
f _{clock}	Clock frequency for LVDS interface, DCLK (all channels)		460	MHz
ENVIRONMENTAL				
T _{ARRAY} and T _{WINDOW}	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 (non-condensing)		81	°C

- (1) All voltages are referenced to common ground VSS. Supply voltages VCC, VCCI, VOFFSET, VBIAS, and VRESET are all required for proper DMD operation. VSS must also be connected.
- (2) VOFFSET supply transients must fall within specified voltages.
- (3) To prevent excess current, the supply voltage change |VCCI – VCC| must be less than specified limit.
- (4) To prevent excess current, the supply voltage change |VBIAS – VOFFSET| must be less than specified limit. Refer to [Section 7](#) for additional information.
- (5) This maximum LVDS input voltage rating applies when each input of a differential pair is at the same voltage potential.
- (6) LVDS 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 by [Section 6.6](#)) or of any point along the Window Edge as defined in [Figure 6-1](#). The locations of thermal test points TP2, TP3, TP4, and TP5 in [Figure 6-1](#) 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, add a test point to that location.
- (8) Temperature delta is the highest difference between the ceramic test point 1 (TP1) and anywhere on the window edge as shown in [Figure 6-1](#). The window test points TP2, TP3, TP4, and TP5 in [Figure 6-1](#) 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.

5.2 Storage Conditions

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

		MIN	MAX	UNIT
T _{DMD}	DMD storage temperature	–40	80	°C
T _{DP-AVG}	Average dew point temperature (non-condensing) ⁽¹⁾		28	°C
T _{DP-ELR}	Elevated dew point temperature range (non-condensing) ⁽²⁾	28	36	°C

5.2 Storage Conditions (continued)

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

		MIN	MAX	UNIT
CT _{ELR}	Cumulative time in elevated dew point temperature range		24	Months

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

5.3 ESD Ratings

		VALUE	UNIT
V _(ESD)	Electrostatic discharge Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 ⁽¹⁾	±2000	V

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

5.4 Recommended Operating Conditions

Over operating free-air temperature range (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 this table. No level of performance is implied when operating the device above or below these limits.

		MIN	NOM	MAX	UNIT
SUPPLY VOLTAGES ^{(1) (2)}					
VCC	Supply voltage for LVCMOS core logic	3.15	3.3	3.45	V
VCCI	Supply voltage for LVDS receivers	3.15	3.3	3.45	V
VOFFSET	Supply voltage for HVCMOS and micromirror electrodes ⁽²⁾	8.25	8.5	8.75	V
VBIAS	Supply voltage for micromirror electrodes	15.5	16	16.5	V
VRESET	Supply voltage for micromirror electrodes	–9.5	–10	–10.5	V
VCCI–VCC	Supply voltage change (absolute value) ⁽³⁾		0	0.3	V
VBIAS–VOFFSET	Supply voltage change (absolute value) ⁽⁴⁾			8.75	V
LVCMOS PINS					
V _{IH}	High level Input voltage ⁽⁵⁾	1.7	2.5	VCC + 0.15	V
V _{IL}	Low level Input voltage ⁽⁵⁾	–0.3		0.7	V
I _{OH}	High level output current at V _{OH} = 2.4V			–20	mA
I _{OL}	Low level output current at V _{OL} = 0.4V			15	mA
t _{PWRDNZ}	PWRDNZ pulse width ⁽⁶⁾	10			ns
SCP INTERFACE					
f _{SCPCLK}	SCP clock frequency ⁽⁷⁾			500	kHz
t _{SCP_DS}	SCPDI clock setup time (before SCPCLK falling-edge) ⁽⁸⁾	800			ns
t _{SCP_DH}	SCPDI hold time (after SCPCLK falling-edge) ⁽⁸⁾	900			ns
t _{SCP_BYTE_INTERVAL}	Time between consecutive bytes	1			μs
t _{SCP_NEG_ENZ}	Time between falling edge of SCPENZ and the first rising edge of SCPCLK	30			ns
t _{SCP_PW_ENZ}	SCPENZ inactive pulse width (high level)	1			μs
t _{SCP_OUT_EN}	Time required for SCP output buffer to recover after SCPENZ (from tristate)			1.5	ns
f _{clock}	SCP circuit clock oscillator frequency ⁽⁹⁾	9.6		11.1	MHz

5.4 Recommended Operating Conditions (continued)

Over operating free-air temperature range (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 this table. No level of performance is implied when operating the device above or below these limits.

		MIN	NOM	MAX	UNIT
LVDS INTERFACE					
f_{clock}	Clock frequency for LVDS interface, DCLK (all channels)			400	MHz
$ V_{\text{ID}} $	Input differential voltage (absolute value) ⁽¹⁰⁾	100	400	600	mV
V_{CM}	Common mode ⁽¹⁰⁾		1200		mV
V_{LVDS}	LVDS voltage ⁽¹⁰⁾	0		2000	mV
$t_{\text{LVDS_RSTZ}}$	Time required for LVDS receivers to recover from PWRDNZ			10	ns
Z_{IN}	Internal differential termination resistance	95		105	Ω
Z_{LINE}	Line differential impedance (PWB/trace)	90	100	110	Ω
ENVIRONMENTAL					
T_{ARRAY}	Array temperature, long-term operational ^{(11) (12) (13)}	10		40 to 70 ⁽¹⁴⁾	$^{\circ}\text{C}$
	Array temperature, short-term operational, 500-hr max ^{(12) (15)}	0		10	
T_{WINDOW}	Window temperature – operational ⁽¹⁶⁾			85	$^{\circ}\text{C}$
$T_{ \text{DELTA} }$	Absolute temperature delta between any point on the window edge and the ceramic test point TP1. ^{(17) (18)}			26	$^{\circ}\text{C}$
$T_{\text{DP-AVG}}$	Average dew point temperature (non-condensing) ⁽¹⁹⁾			28	$^{\circ}\text{C}$
$T_{\text{DP-ELR}}$	Elevated dew point temperature range (non-condensing) ⁽²⁰⁾	28		36	$^{\circ}\text{C}$
CT_{ELR}	Cumulative time in elevated dew point temperature range			24	Months
SOLID STATE ILLUMINATION					
ILL_{UV}	Illumination power at wavelengths < 410nm ^{(11) (22)}			10	mW/cm ²
ILL_{VIS}	Illumination power at wavelengths $\geq$ 410nm and $\leq$ 800nm ^{(21) (22)}			23.7	W/cm ²
ILL_{IR}	Illumination power at wavelengths > 800nm ⁽²²⁾			10	mW/cm ²
ILL_{BLU}	Illumination power at wavelengths $\geq$ 410nm and $\leq$ 475nm ^{(21) (22)}			7.5	W/cm ²
ILL_{BLU1}	Illumination power at wavelengths $\geq$ 410nm and $\leq$ 440nm ^{(21) (22)}			1.3	W/cm ²
LAMP ILLUMINATION					
ILL_{UV}	Illumination power at wavelengths < 395nm ^{(11) (22)}			2.0	mW/cm ²
ILL_{VIS}	Illumination power at wavelengths $\geq$ 395nm and $\leq$ 800nm ^{(21) (22)}			23.7	W/cm ²
ILL_{IR}	Illumination power at wavelengths > 800nm ⁽²²⁾			10	mW/cm ²

- (1) Supply voltages VCC, VCCI, VOFFSET, VBIAS, and VRESET are all required for proper DMD operation. VSS must also be connected.
- (2) VOFFSET supply transients must fall within specified max voltages.
- (3) To prevent excess current, the supply voltage change $|V_{\text{CCI}} - V_{\text{CC}}|$ must be less than specified limit.
- (4) To prevent excess current, the supply voltage change $|V_{\text{BIAS}} - V_{\text{OFFSET}}|$ must be less than the specified limit. Refer to [Section 7](#) for additional information.
- (5) Tester conditions for V_{IH} and V_{IL} :
Frequency = 60MHz. Maximum Rise Time = 2.5ns at (20% to 80%)
Frequency = 60MHz. Maximum Fall Time = 2.5ns at (80% to 20%)
- (6) PWRDNZ input pin resets the SCP and disables the LVDS receivers. PWRDNZ input pin overrides SCPENZ input pin and tri-states the SCPDO output pin.
- (7) The SCP clock is a gated clock. Duty cycle shall be $50\% \pm 10\%$. SCP parameter is related to the frequency of DCLK.
- (8) Refer to [Figure 5-2](#).
- (9) SCP internal oscillator is specified to operate all SCP registers. For all SCP operations, DCLK is required.
- (10) Refer to [Figure 5-3](#), [Figure 5-4](#), and [Figure 5-5](#).
- (11) Simultaneous exposure of the DMD to the maximum [Section 5.4](#) for temperature and UV illumination reduces device lifetime.
- (12) The array temperature cannot be measured directly and must be computed analytically from the temperature measured at test point 1 (TP1) shown in [Figure 6-1](#) and the package [thermal resistance](#) using the calculation in [Section 6.6](#).
- (13) Long-term is defined as the average over the usable life.
- (14) Per [Figure 5-1](#), the maximum operational array temperature should be derated based on the micromirror landed duty cycle that the DMD experiences in the end application. See [Section 6.8](#).
- (15) Short-term is defined as cumulative time over the usable life of the device.

- (16) The locations of thermal test points TP2, TP3, TP4, and TP5 in [Figure 6-1](#) 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.
- (17) Temperature delta is the highest difference between the ceramic test point 1 (TP1) and anywhere on the window edge as shown in [Figure 6-1](#). The window test points TP2, TP3, TP4, and TP5 shown in [Figure 6-1](#) 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.
- (18) DMD is qualified at the combination of the maximum temperature and maximum lumens specified. Operation of the DMD outside of these limits has not been tested.
- (19) The average over time (including storage and operating) that the device is not in the 'elevated dew point temperature range'.
- (20) 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} .
- (21) The maximum allowable optical power incident on the DMD is limited by the maximum optical power density for each wavelength range specified and the micromirror array temperature (T_{ARRAY}).
- (22) To calculate see [Section 6.7](#).

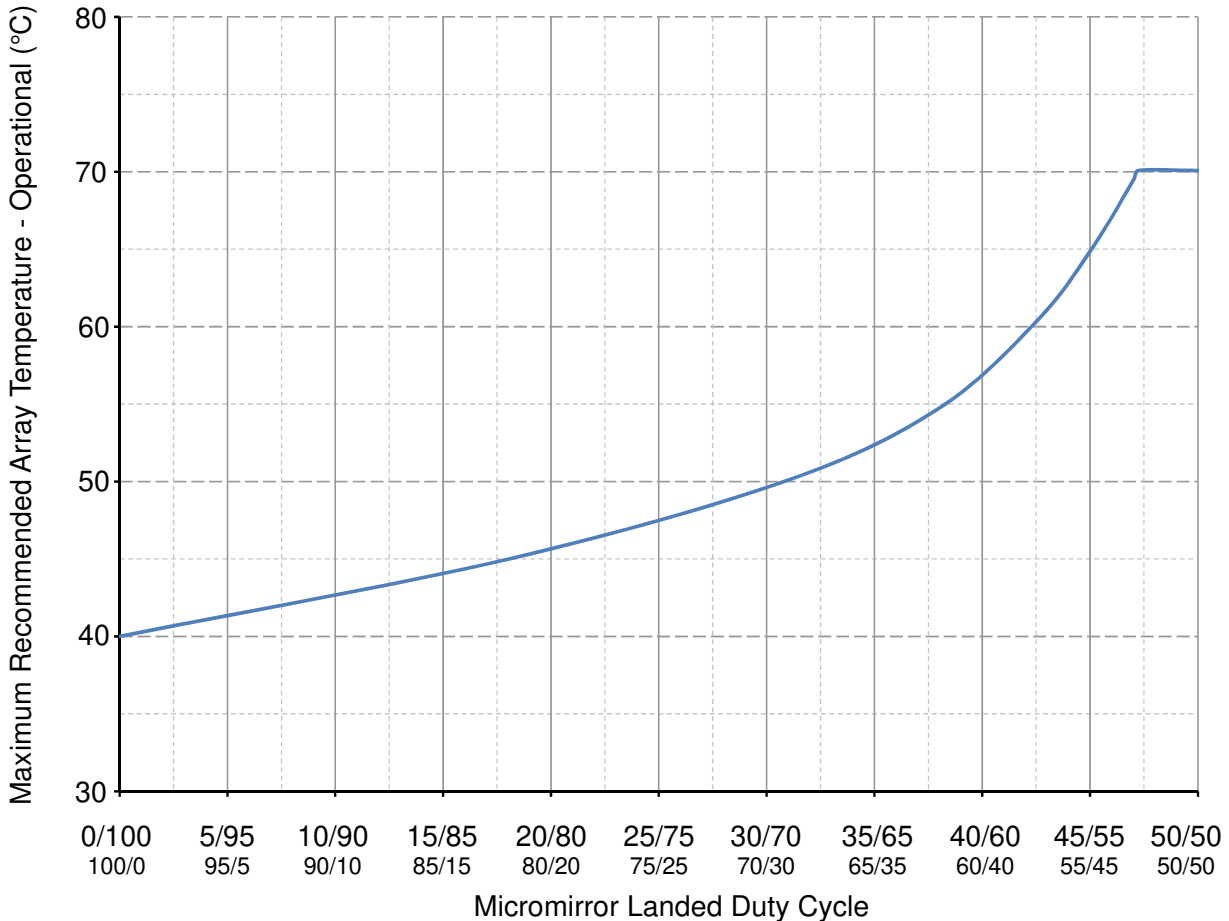


Figure 5-1. Recommended Maximum DMD Temperature—Derating Curve

5.5 Thermal Information

THERMAL METRIC ⁽¹⁾	DLP650NE	UNIT
	FYE Package	
	350 PINS	
Thermal resistance from active array to test point 1 (TP1)	0.6	°C/W

- (1) The DMD is designed to conduct absorbed and dissipated heat to the back of the package where it can be removed by an appropriate heat sink. The heat sink and cooling system must be capable of maintaining the package within the temperature range specified in the [Recommended Operating Conditions](#).
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.

5.6 Electrical Characteristics

Over operating free-air temperature range (unless otherwise noted).

PARAMETER		TEST CONDITIONS ⁽¹⁾	MIN	TYP	MAX	UNIT	
V _{OH}	High-level output voltage	VCC = 3.3 V, I _{OH} = −20 mA	2.4			V	
V _{OL}	Low -level output voltage	VCC = 3.45 V, I _{OL} = 15 mA	0.4			V	
I _{IH}	High-level input current ^{(2) (3)}	VCC = 3.45 V, V _I = VCC	250			μA	
I _{IL}	Low-level input current	VCC = 3.45 V, V _I = 0	−250			μA	
I _{OZ}	High-impedance output current	VCC = 3.45 V	10			μA	
I _{CC}	Supply current ⁽⁴⁾	VCC = 3.45 V	1100			mA	
I _{CCI}		VCCI = 3.45 V	500				
I _{OFFSET}	Supply current ⁽⁵⁾	VOFFSET = 8.75 V	10			mA	
I _{BIAS}		VBIAS = 16.5 V	10				
I _{RESET}	Supply current	VRESET = −10.5 V	10			mA	
I _{TOTAL}		Total Sum	1650				
C _I	Input capacitance	f = 1 MHz	10			pF	
C _O	Output capacitance	f = 1 MHz	10			pF	
C _M	Reset group capacitance MBRST(14:0)	f = 1 MHz all inputs interconnected, (1920 x 1080) array	330			390	pF

- (1) All voltages are referenced to common ground VSS. Supply voltages VCC, VCCI, VOFFSET, VBIAS, and VRESET are all required for proper DMD operation. VSS must also be connected.
- (2) Applies to LVCMOS input pins only; excludes the LVDS pins and MBRST pins
- (3) LVCMOS input pins utilize an internal 18000-Ω passive resistor for pullup and pulldown configurations. Refer to [Section 4](#) to determine the pullup or pulldown configuration used.
- (4) To prevent excess current, the supply voltage change |VCCI – VCC| must be less than specified limit.
- (5) To prevent excess current, the supply voltage change |VBIAS – VOFFSET| must be less than specified limit.

5.7 Timing Requirements

Over Recommended Operating Conditions (Section 5.4) unless otherwise noted.⁽⁵⁾

DESCRIPTION ⁽¹⁾			MIN	TYP	MAX	UNIT
SCP INTERFACE ⁽²⁾						
t _r	Rise time	20% to 80% reference points			200	ns
t _f	Fall time	80% to 20% reference points			200	ns
LVDS INTERFACE ⁽²⁾						
t _r	Rise time	20% to 80%	100		400	ps
t _f	Fall time	80% to 20%	100		400	ps
LVDS CLOCKS ⁽³⁾						
t _c	Cycle time	DCLK_A, 50% to 50%	2.5			ns
		DCLK_B, 50% to 50%	2.5			
t _w	Pulse duration	DCLK_A, 50% to 50%	1.19	1.25		ns
		DCLK_B, 50% to 50%	1.19	1.25		
LVDS INTERFACE ⁽³⁾						
t _{su}	Setup time	D_A(15:0) before rising or falling edge of DCLK_A	0.1			ns
		D_B(15:0) before rising or falling edge of DCLK_B	0.1			
t _{su}	Setup time	SCTRL_A before rising or falling edge of DCLK_A	0.1			ns
		SCTRL_B before rising or falling edge of DCLK_B	0.1			
t _h	Hold time	D_A(15:0) after rising or falling edge of DCLK_A	0.4			ns
		D_B(15:0) after rising or falling edge of DCLK_B	0.4			
t _h	Hold time	SCTRL_A after rising or falling edge of DCLK_A	0.3			ns
		SCTRL_B after rising or falling edge of DCLK_B	0.3			
LVDS INTERFACE ⁽⁴⁾						
t _{skew}	Skew time	Channel B relative to Channel A ⁽⁴⁾	Channel A includes the following LVDS pairs: DCLK_AP and DCLK_AN SCTRL_AP and SCTRL_AN D_AP(15:0) and D_AN(15:0)	-1.25	1.25	ns

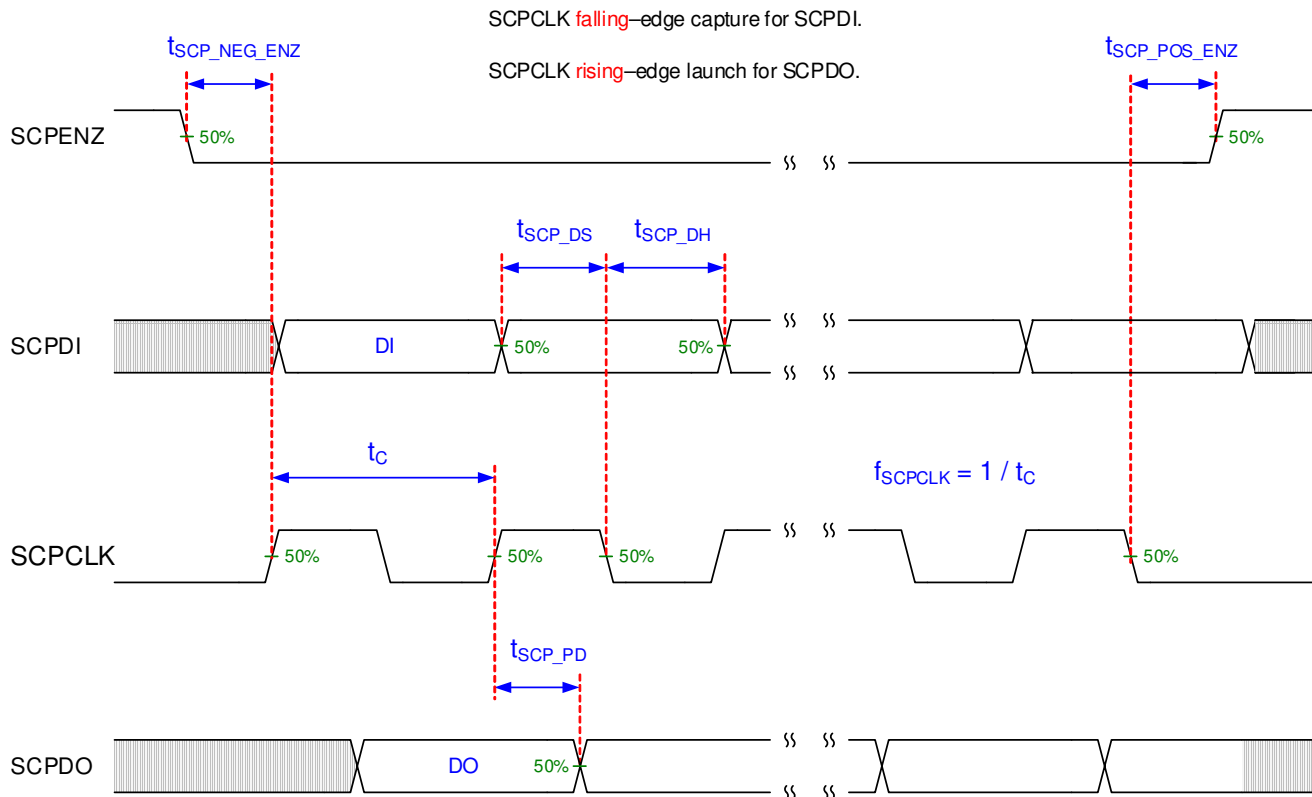
(1) Refer to Section 4 for pin details.

(2) Refer to Figure 5-6.

(3) Refer to Figure 5-8.

(4) Refer to Figure 5-9.

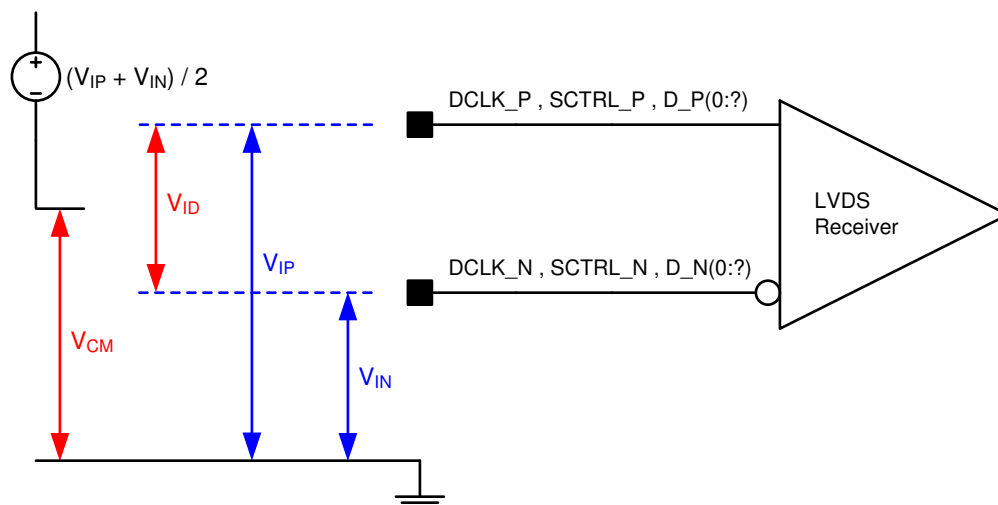
(5) Tested at the device pin. For output timing analysis, the tester pin electronics and its transmission line effects must be considered.



Not to scale

Refer to the SCP Interface section of the *Recommended Operating Conditions* [Section 5.4](#).

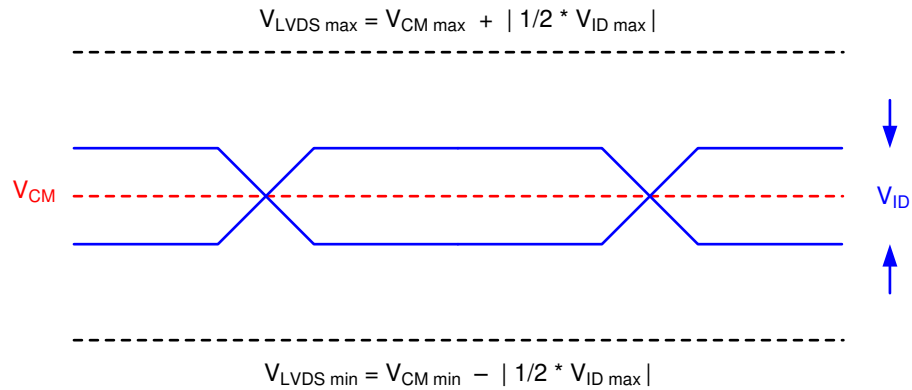
Figure 5-2. SCP Timing Parameters



Refer to the LVDS Interface section of the *Recommended Operating Conditions* ([Section 5.4](#)).

Refer to the Pin Functions table for the list of LVDS pins.

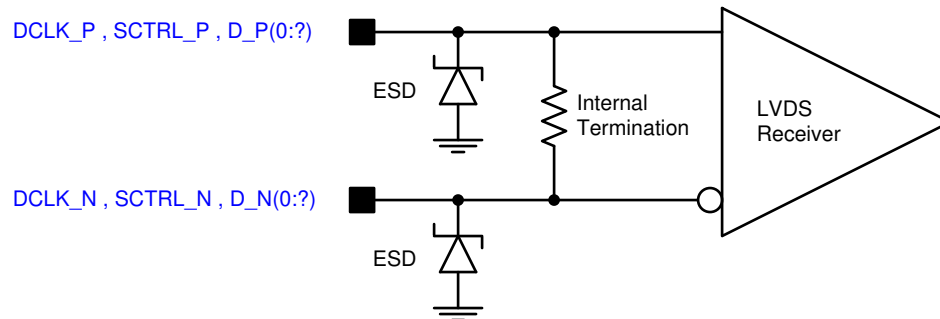
Figure 5-3. LVDS Voltage Definitions (References)



Not to scale

Refer to the LVDS Interface section of the *Recommended Operating Conditions* (Section 5.4).

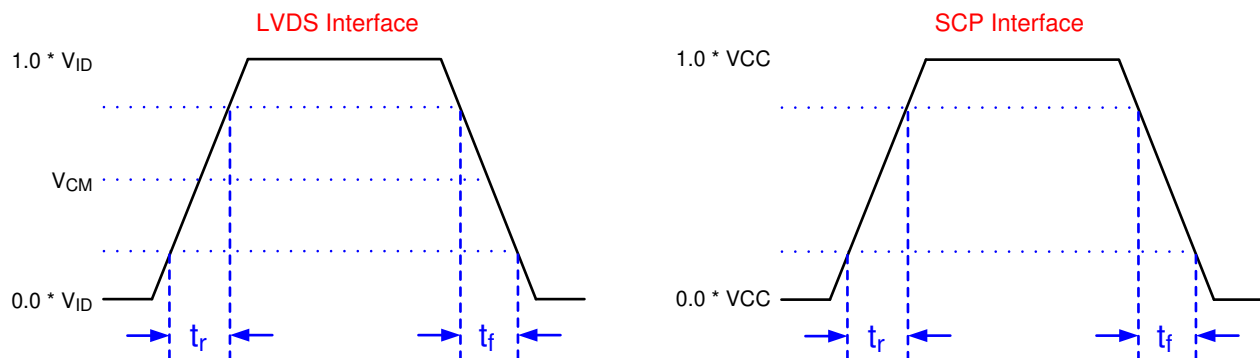
Figure 5-4. LVDS Voltage Parameters



Refer to the LVDS Interface section of the *Recommended Operating Conditions* (Section 5.4).

Refer to the Pin Functions table for the list of LVDS pins.

Figure 5-5. LVDS Equivalent Input Circuit



Not to scale

Refer to the timing requirements.

Refer to the Pin Functions table for the list of LVDS pins and SCP pins.

Figure 5-6. Rise Time and Fall Time

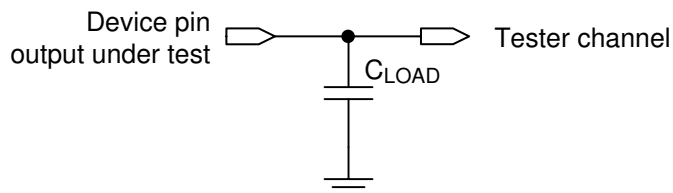
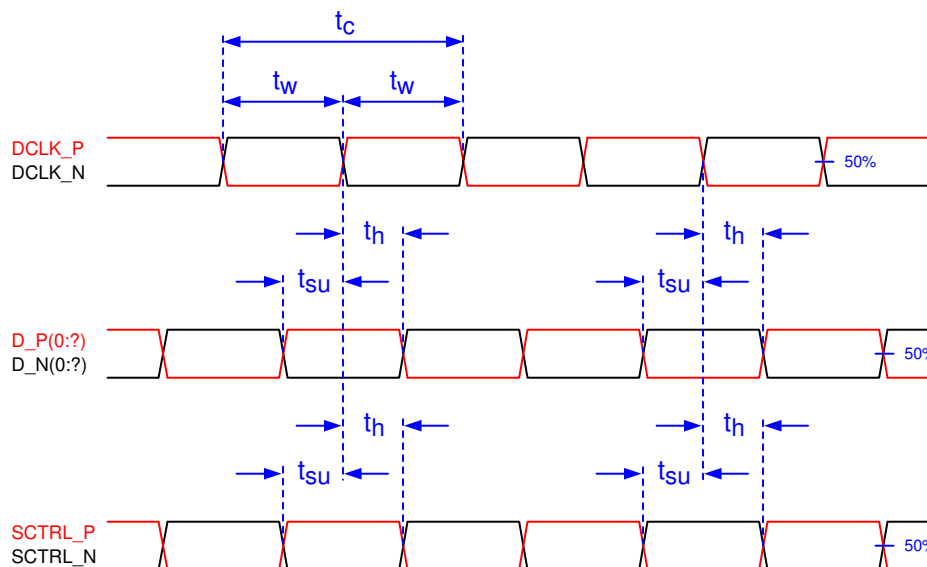


Figure 5-7. Test Load Circuit for Output Propagation Measurement

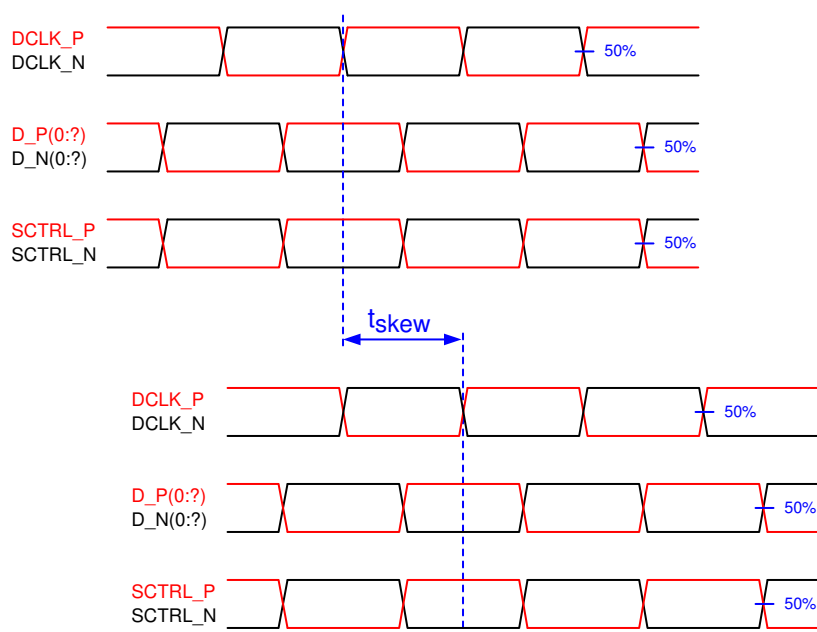
For output timing analysis, the tester pin electronics and its transmission line effects must be considered. System design should use IBIS or other simulation tools to correlate the timing reference load to a system environment. See [Figure 5-7](#).



Not to scale

Refer to the LVDS Interface section in the timing requirements.

Figure 5-8. Timing Requirement Parameter Definitions



Not to scale

Refer to the *LVDS Interface* section in the timing requirements.

Figure 5-9. LVDS Interface Channel Skew Definition

5.8 Window Characteristics

PARAMETER	MIN	NOM
Window material		Corning Eagle XG
Window refractive index at wavelength 546.1 nm		1.5119
Window Transmittance, minimum within the wavelength range 420–680 nm. Applies to all angles 0–30° AOI. ⁽¹⁾ ⁽²⁾	97%	
Window Transmittance, average over the wavelength range 420–680 nm. Applies to all angles 30–45° AOI. ⁽¹⁾ ⁽²⁾	97%	

(1) Single-pass through both surfaces and glass

(2) Angle of incidence (AOI) is the angle between an incident ray and the normal to a reflecting or refracting surface.

5.9 System Mounting Interface Loads

PARAMETER	MIN	NOM	MAX	UNIT
Condition 1: ⁽¹⁾				
• Thermal Interface area			11.3	kg
• Electrical Interface area			11.3	kg

(1) Uniformly distributed within area shown in [Figure 5-10](#)

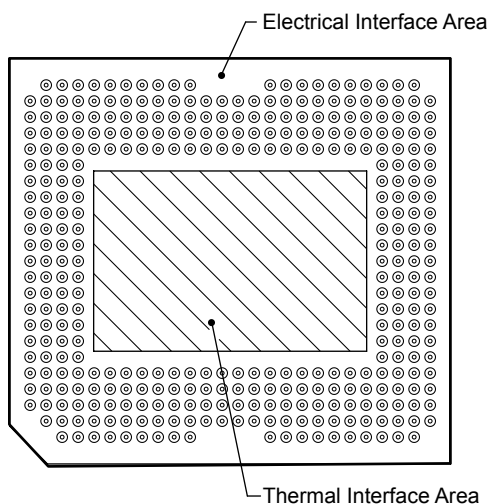


Figure 5-10. System Mounting Interface Loads

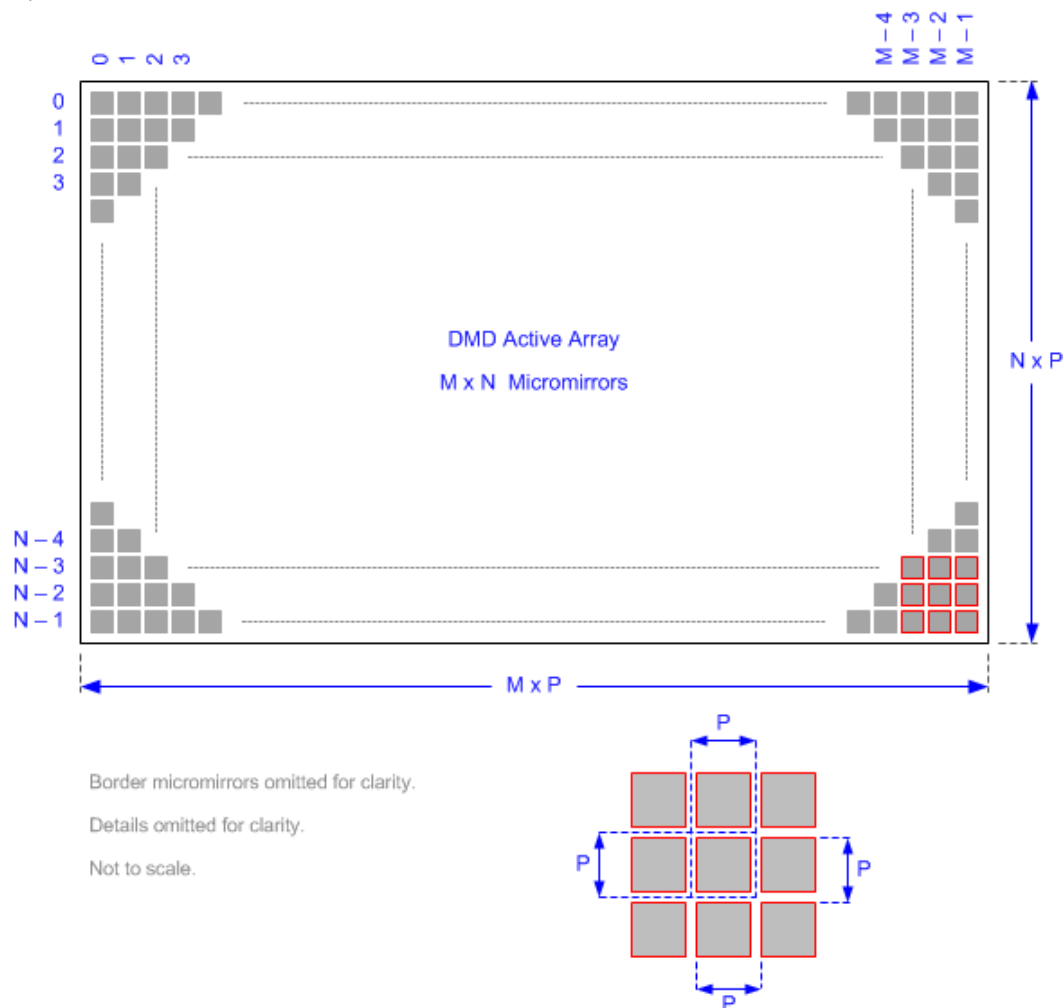
5.10 Micromirror Array Physical Characteristics

		VALUE	UNIT
Number of active columns ⁽¹⁾	M	1920	micromirrors
Number of active rows ⁽¹⁾	N	1080	micromirrors
Micromirror (pixel) pitch ⁽¹⁾	P	7.56	μm
Micromirror active array width ⁽¹⁾	Micromirror Pitch × number of active columns	14.5152	mm
Micromirror active array height ⁽¹⁾	Micromirror Pitch × number of active rows	8.1648	mm

5.10 Micromirror Array Physical Characteristics (continued)

		VALUE	UNIT
Micromirror active border ⁽²⁾	Pond of micromirrors (POM)	14	micromirrors /side

- (1) See [Figure 5-11](#).
- (2) 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 OFF.



Refer to [Micromirror Array Physical Characteristics](#) for M, N, and P specifications.

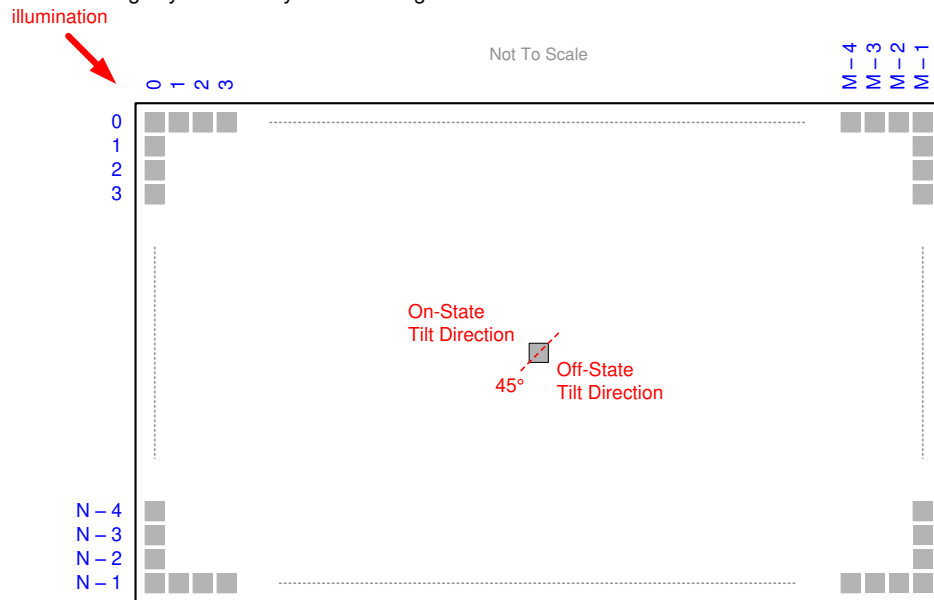
Figure 5-11. Micromirror Array Physical Characteristics

5.11 Micromirror Array Optical Characteristics

See [Section 6.5](#) for important information.

PARAMETER		TEST CONDITION	MIN	NOM	MAX	UNIT
Micromirror tilt angle, variation device to device ⁽²⁾ ⁽³⁾ ⁽⁴⁾ ⁽⁵⁾		Landed State ⁽¹⁾	11	12	13	degrees
Image performance ⁽⁶⁾	Bright pixel(s) in active area ⁽⁷⁾	Gray 10 screen ⁽¹⁰⁾			0	micromirrors
	Bright pixel(s) in the POM ⁽⁷⁾ ⁽⁹⁾	Gray 10 screen ⁽¹⁰⁾			1	
	Dark pixel(s) in the active area ⁽⁸⁾	White screen ⁽¹¹⁾			4	
	Adjacent pixel(s) ⁽¹²⁾	Any screen			0	
	Unstable pixel(s) in active area ⁽¹³⁾	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) This represents the variation that can occur between any two individual micromirrors, located on the same device or located on different devices.
- (4) 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 variations 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.
- (5) See figure [Figure 5-12](#).
- (6) Conditions of acceptance. All DMD image performance returns are 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 60 inches.
 - The projections screen shall be a 1× gain.
 - The projected image shall be inspected from an 8-foot minimum viewing distance.
 - The image shall be in focus during all image performance tests.
- (7) Bright pixel definition: a single pixel or mirror that is stuck in the ON position and is visibly brighter than the surrounding pixels.
- (8) Dark pixel definition: a single pixel or mirror that is stuck in the OFF position and is visibly darker than the surrounding pixels.
- (9) POM definition: The rectangular border of off-state mirrors surrounding the active area.
- (10) Gray 10 screen definition: A full screen with RGB values set to R=10/255, G=10/255, B=10/255.
- (11) White screen definition: A full screen with RGB values set to R=255/255, G=255/255, B=255/255.
- (12) Adjacent pixel definition: Two or more stuck pixels sharing a common border or common point. Also referred to as a cluster.
- (13) 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.



Refer to [Micromirror Array Physical Characteristics](#) for M, N, and P specifications.

Figure 5-12. Micromirror Landed Orientation and Tilt

5.12 Chipset Component Usage Specification

The DLP650NE is a component of one or more DLP chipsets. Reliable function and operation of the DLP650NE require that it is 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 is the TI technology and devices for operating or controlling a DLP DMD.

6 Detailed Description

6.1 Overview

DLP650NE is a 0.65-inch diagonal spatial light modulator which consists of an array of highly reflective aluminum micromirrors. Pixel array size and square grid pixel arrangement are shown in [Figure 5-11](#).

The DMD is an electrical input, optical output micro-electrical-mechanical system (MEMS). The electrical interface is low voltage differential signaling (LVDS), double data rate (DDR).

DLP650NE 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 [Functional Block Diagram](#).

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).

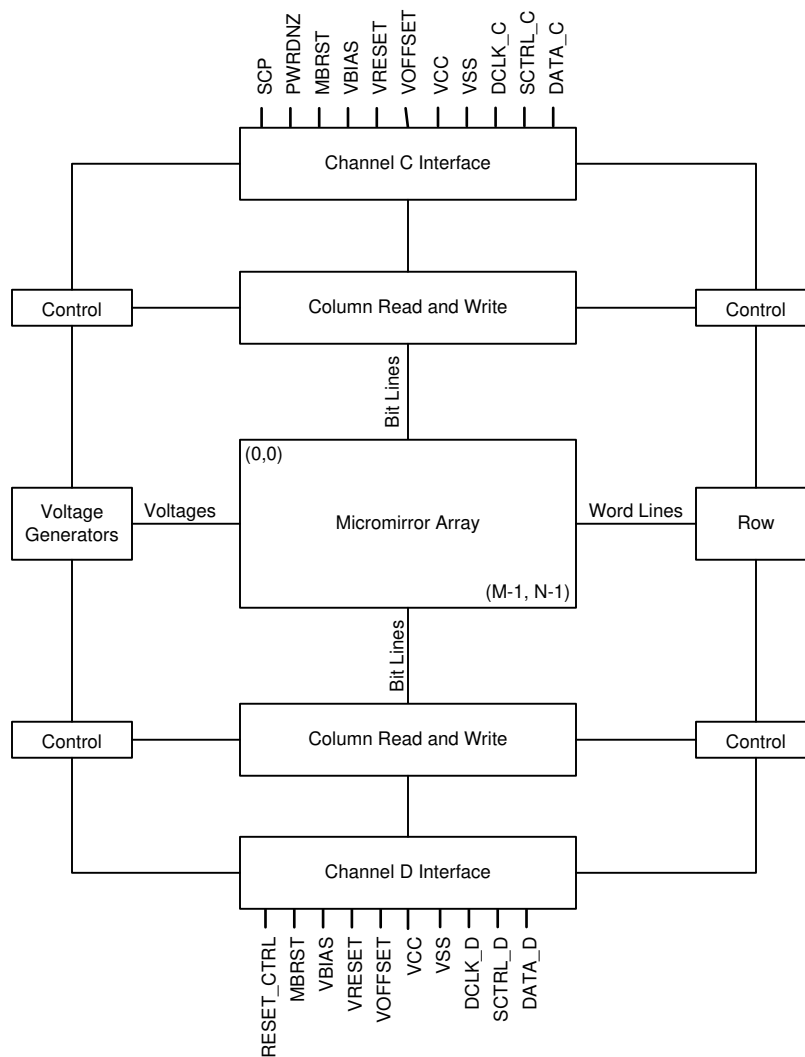
Each cell of the $M \times N$ memory array drives its true and complement ('Q' and 'QB') data to two electrodes underlying one micromirror, one electrode on each side of the diagonal axis of rotation. Refer to [Section 5.11](#). The micromirrors are electrically tied to the micromirror reset signals (MBRST) and the micromirror array is divided into reset groups.

Electrostatic potentials between a micromirror and its memory data electrodes cause the micromirror to tilt toward the illumination source in a DLP projection system or away from it, thus reflecting its incident light into or out of an optical collection aperture. The positive (+) tilt angle state corresponds to an 'on' pixel, and the negative (–) tilt angle state corresponds to an 'off' pixel.

Refer to [Micromirror Array Optical Characteristics](#) for the $\pm$ tilt angle specifications. Refer to [Section 4](#) for more information on micromirror reset control.

6.2 Functional Block Diagram

The main LVDS lines going to the DMD are connected through channels A and B. However, the LVDS lines come from channels C and D off the DLPC4420. Please refer to the [DLPC4420 controller data sheet](#) for more information.



For pin details on channels A, B, C, and D, refer to [Section 4](#) and LVDS Interface section of [Timing Requirements](#).

6.3 Feature Description

6.3.1 Power Interface

The DMD requires four DC voltage input signals.

- DMD_P3P3V
- VOFFSET
- VRESET
- VBIAS

The DMD_P3P3V signal is created by the power and motor driver of the DLPA100 device. It is used on the DMD board to create the other three DMD voltage inputs, as well as powering various peripherals (for example, TMP411, I²C, and TI level translators). The other signals (VOFFSET (8.5V), VRESET (–10V), and VBIAS (16.5V)) are created by the TI PMIC TPS65145 device and are supplied to the DMD to control the micromirrors.

6.3.2 Timing

The data sheet provides a timing analysis as measured at the device pin. For an output timing analysis, the tester pin electronics and its transmission line effects must be considered. [Figure 5-7](#) shows an equivalent test load circuit for the output under test. Timing reference loads are not intended as a precise representation of any particular system environment or depiction of the actual load presented by a production test. TI suggests that system designers 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.

6.4 Device Functional Modes

DMD functional modes are controlled by the DLPC4420 digital display controller. See the [DLPC4420 controller data sheet](#). Contact a TI applications engineer for more information.

6.5 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. System optical performance and image quality strongly relate to optical system design parameter trades offs. 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.

6.5.1 Numerical Aperture and Stray Light Control

The angle defined by the numerical aperture of the illumination and projection optics at the DMD optical area is the same. This angle should not exceed the nominal device mirror tilt angle unless appropriate apertures are added in the illumination and projection pupils to block out flat-state and stray light from the projection lens. The micromirror tilt angle defines the 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 mirror tilt angle, or if the projection numerical aperture angle is more than two degrees larger than the illumination numerical aperture angle (and vice versa), objectionable artifacts in the display's border and active area could occur.

6.5.2 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's 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.

6.5.3 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. The aperture 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. Design the illumination optical system 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's optical architecture, overfill light may have to be further reduced below the suggested 10% level to be acceptable.

6.6 Micromirror Array Temperature Calculation

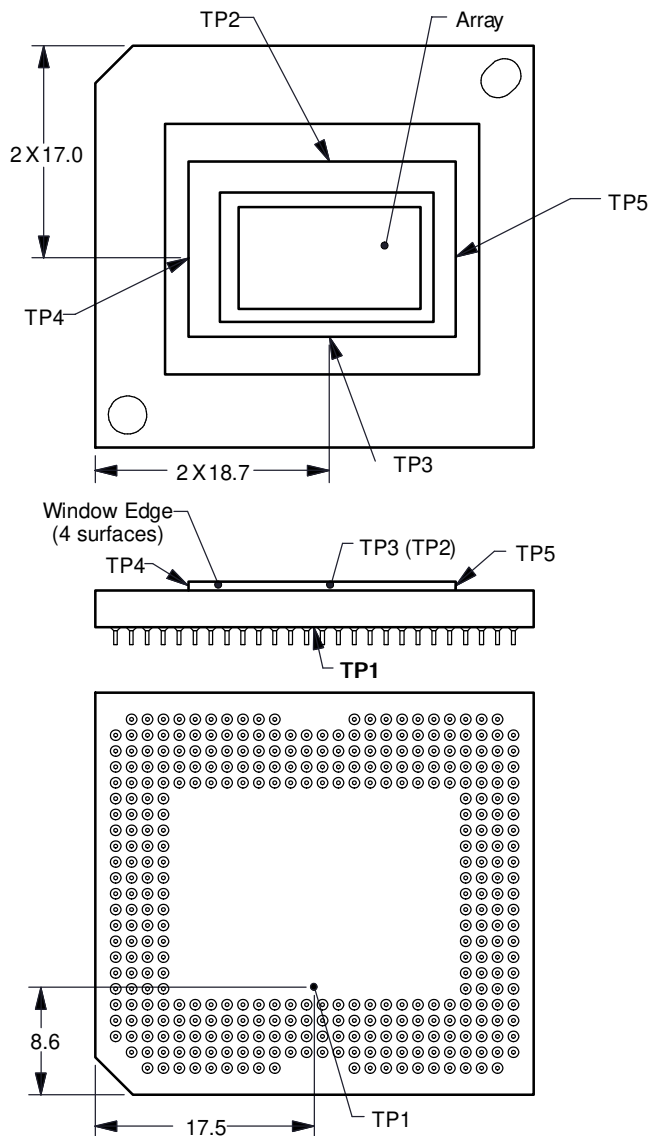


Figure 6-1. DMD Thermal Test Points

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 following equations show the relationship between array temperature and the reference ceramic temperature, thermal test TP1 [Figure 6-1](#) shown above:

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

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

where

- T_{ARRAY} = Computed array temperature ($^{\circ}\text{C}$)
- T_{CERAMIC} = Measured ceramic temperature ($^{\circ}\text{C}$), TP1 [Figure 6-1](#)
- $R_{\text{ARRAY-TO-CERAMIC}}$ = Thermal resistance of package specified in [Section 5.5](#) from array to ceramic TP1 [Figure 6-1](#) ($^{\circ}\text{C}/\text{W}$).
- Q_{ARRAY} = Total DMD Power (electrical + absorbed) on array (W).
- $Q_{\text{ELECTRICAL}}$ = Nominal electrical power (W)
- Q_{INCIDENT} = Incident illumination optical power (W)
- $Q_{\text{ILLUMINATION}}$ = (DMD average thermal absorptivity $\times$ Q_{INCIDENT}) (W)
- DMD average thermal absorptivity = 0.45

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 2.9W. The absorbed optical 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 single chip or multichip DMD system. It assumes an 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:

$$Q_{\text{INCIDENT}} = 32\text{W (measured)}$$

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

$$Q_{\text{ELECTRICAL}} = 2.9\text{W}$$

$$Q_{\text{ARRAY}} = 2.9\text{W} + (0.45 \times 32\text{W}) = 17.3\text{W}$$

$$T_{\text{ARRAY}} = 55.0^{\circ}\text{C} + (17.3\text{W} \times 0.60^{\circ}\text{C}/\text{W}) = 65.4^{\circ}\text{C}$$

6.7 Micromirror Power Density Calculation

The calculation of the optical power density of the illumination on the DMD in the different wavelength bands uses the total measured optical power on the DMD, percent illumination overfill, area of the active array, and the ratio of the spectrum in the wavelength band of interest to the total spectral optical power.

- $ILL_{\text{UV}} = [OP_{\text{UV-RATIO}} \times Q_{\text{INCIDENT}}] \times 1000\text{mW}/\text{W} \div A_{\text{ILL}}$ (mW/cm^2)
- $ILL_{\text{VIS}} = [OP_{\text{VIS-RATIO}} \times Q_{\text{INCIDENT}}] \div A_{\text{ILL}}$ (W/cm^2)
- $ILL_{\text{IR}} = [OP_{\text{IR-RATIO}} \times Q_{\text{INCIDENT}}] \times 1000\text{mW}/\text{W} \div A_{\text{ILL}}$ (mW/cm^2)
- $ILL_{\text{BLU}} = [OP_{\text{BLU-RATIO}} \times Q_{\text{INCIDENT}}] \div A_{\text{ILL}}$ (W/cm^2)
- $ILL_{\text{BLU1}} = [OP_{\text{BLU1-RATIO}} \times Q_{\text{INCIDENT}}] \div A_{\text{ILL}}$ (W/cm^2)
- $A_{\text{ILL}} = A_{\text{ARRAY}} \div (1 - OV_{\text{ILL}})$ (cm^2)

where:

- ILL_{UV} = UV illumination power density on the DMD (mW/cm^2)
- ILL_{VIS} = VIS illumination power density on the DMD (W/cm^2)
- ILL_{IR} = IR illumination power density on the DMD (mW/cm^2)
- ILL_{BLU} = BLU illumination power density on the DMD (W/cm^2)
- ILL_{BLU1} = BLU1 illumination power density on the DMD (W/cm^2)

- A_{ILL} = illumination area on the DMD (cm^2)
- $Q_{INCIDENT}$ = total incident optical power on DMD (W) (measured)
- A_{ARRAY} = area of the array (cm^2) (data sheet)
- OV_{ILL} = percent of total illumination on the DMD outside the array (%) (optical model)
- $OP_{UV-RATIO}$ = ratio of the optical power for wavelengths $<410\text{nm}$ to the total optical power in the illumination spectrum (spectral measurement)
- $OP_{VIS-RATIO}$ = ratio of the optical power for wavelengths ≥ 410 and $\leq 800\text{nm}$ to the total optical power in the illumination spectrum (spectral measurement)
- $OP_{IR-RATIO}$ = ratio of the optical power for wavelengths $>800\text{nm}$ to the total optical power in the illumination spectrum (spectral measurement)
- $OP_{BLU-RATIO}$ = ratio of the optical power for wavelengths ≥ 410 and $\leq 475\text{nm}$ to the total optical power in the illumination spectrum (spectral measurement)
- $OP_{BLU1-RATIO}$ = ratio of the optical power for wavelengths ≥ 410 and $\leq 440\text{nm}$ to the total optical power in the illumination spectrum (spectral measurement)

The illumination area varies and depends on the illumination overfill. The total illumination area on the DMD is the array area and the overfill area around the array. The optical model is used to determine the percent of the total illumination on the DMD that is outside the array (OV_{ILL}) and the percent of the total illumination that is on the active array. From these values, the illumination area (A_{ILL}) is calculated. The illumination is assumed to be uniform across the entire array.

From the measured illumination spectrum, the ratio of the optical power in the wavelength bands of interest to the total optical power is calculated.

Sample calculation:

$$Q_{INCIDENT} = 32\text{W (measured)}$$

$$A_{ARRAY} = (14.5152\text{mm} \times 8.1648\text{mm}) \div 100\text{mm}^2/\text{cm}^2 = 1.1851\text{cm}^2 \text{ (data sheet)}$$

$$OV_{ILL} = 16.3\% \text{ (optical model)}$$

$$OP_{UV-RATIO} = 0.00017 \text{ (spectral measurement)}$$

$$OP_{VIS-RATIO} = 0.99977 \text{ (spectral measurement)}$$

$$OP_{IR-RATIO} = 0.00006 \text{ (spectral measurement)}$$

$$OP_{BLU-RATIO} = 0.28100 \text{ (spectral measurement)}$$

$$OP_{BLU1-RATIO} = 0.03200 \text{ (spectral measurement)}$$

$$A_{ILL} = 1.1851\text{cm}^2 \div (1 - 0.163) = 1.4159\text{cm}^2$$

$$ILL_{UV} = [0.00017 \times 32\text{W}] \times 1000\text{mW/W} \div 1.4159\text{cm}^2 = 3.842\text{mW/cm}^2$$

$$ILL_{VIS} = [0.99977 \times 32\text{W}] \div 1.4159\text{cm}^2 = 22.59\text{W/cm}^2$$

$$ILL_{IR} = [0.00006 \times 32\text{W}] \times 1000\text{mW/W} \div 1.4159\text{cm}^2 = 1.356\text{mW/cm}^2$$

$$ILL_{BLU} = [0.28100 \times 32\text{W}] \div 1.4159\text{cm}^2 = 6.35\text{W/cm}^2$$

$$ILL_{BLU1} = [0.03200 \times 32\text{W}] \div 1.4159\text{cm}^2 = 0.72\text{W/cm}^2$$

6.8 Micromirror Landed-On or Landed-Off Duty Cycle

6.8.1 Definition of Micromirror Landed-On or Landed-Off Duty Cycle

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

As an 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 50% of the time and Off 50% of the time.

Note that when assessing the 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.

6.8.2 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's micromirror array (also called the active array) to an asymmetric landed duty cycle for a prolonged period of time can reduce the DMD's usable 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.

Individual DMD mirror duty cycles vary by application as well as the mirror location on the DMD within any specific application. DMD mirror useful life is maximized when every individual mirror within a DMD approaches a 50/50 (or 1/1) duty cycle. Therefore, for the DLPC4420 and DLP650NE chipset, it is recommended that the DMD Idle Mode be enabled as often as possible. Examples are whenever the system is idle, the illumination is disabled, between sequential pattern exposures (if possible), or when the exposure pattern sequence is stopped for any reason. This software mode provides a 50/50 duty cycle across the entire DMD mirror array, where the mirrors are continuously flipped between the on and off states. Refer to the *DLPC4420 Software Programmer's Guide* for a description of the DMD Idle Mode command. For the DLPC910 and DLP650NE chipset, it is recommended that the controlling applications processor provide a 50/50 pattern sequence to the DLPC910 for display on the DLP650NE as often as possible, similar to the above examples stated for the DLPC4420. The pattern provides a 50/50 duty cycle across the entire DMD mirror array, where the mirrors are continuously flipped between the ON and OFF states.

6.8.3 Landed Duty Cycle and Operational DMD Temperature

Operational DMD Temperature and Landed Duty Cycle interact to affect the DMD usable life, and this interaction can be exploited to reduce the impact that an asymmetrical Landed Duty Cycle has on the usable life of the DMD. This is quantified in the de-rating curve shown in [Figure 5-1](#). The importance of this curve is that:

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

In practice, this curve specifies the maximum operating DMD temperature at a given long-term average Landed Duty Cycle.

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

During a given time period, 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 6-1](#).

Table 6-1. 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.

During a given period of time, the landed duty cycle of a given pixel can be calculated in [Equation 1](#).

$$\text{Landed Duty Cycle} = (\text{Red_Cycle_}\% \times \text{Red_Scale_Value}) + (\text{Green_Cycle_}\% \times \text{Green_Scale_Value}) + (\text{Blue_Cycle_}\% \times \text{Blue_Scale_Value}) \quad (1)$$

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 50%, 20%, and 30%, 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 6-2](#).

Table 6-2. Example Landed Duty Cycle for Full-Color

CYCLE PERCENTAGE			Landed Duty Cycle
Red 50%	Green 20%	Blue 30%	
Red Scale Value	Green Scale Value	Blue Scale Value	
0%	0%	0%	0/100
100%	0%	0%	50/50

Table 6-2. Example Landed Duty Cycle for Full-Color (continued)

CYCLE PERCENTAGE			Landed Duty Cycle
Red 50%	Green 20%	Blue 30%	
Red Scale Value	Green Scale Value	Blue Scale Value	
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

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.

1 Application Information

Texas Instruments DLP technology is a micro-electro-mechanical systems (MEMS) technology that modulates light using a digital micromirror device (DMD). The DMD is a spatial light modulator, which reflects incoming light from an illumination source to one of two directions, towards the projection optics or collection optics. The large micromirror array size and ceramic package provide great thermal performance for bright display applications. Typical applications using the DLP650NE include home theater, digital signage, interactive displays, low-latency gaming displays, portable smart displays.

The following orderables have been replaced by the DLP650NE:

Device Information

PART NUMBER	PACKAGE ⁽¹⁾	BODY SIZE (NOM)	MECHANICAL ICD
DLP650NET	FYE (350)	35.0mm × 32.2mm × 5.1mm	2511543
1910-6232E	FYE (350)	35.0mm × 32.2mm × 5.1mm	2511543
1910-6237E	FYE (350)	35.0mm × 32.2mm × 5.1mm	2511543
1910-6239E	FYE (350)	35.0mm × 32.2mm × 5.1mm	2511543
1910-623AE	FYE (350)	35.0mm × 32.2mm × 5.1mm	2511543

2 Typical Application

The DLP650NE DMD combined with a DLPC4420 (or DLPC4430) digital controller and DLPA100 power management device provides full HD resolution for bright, colorful display applications. A typical display system using the DLP650NE and additional system components can be seen in [Figure 7-1](#).

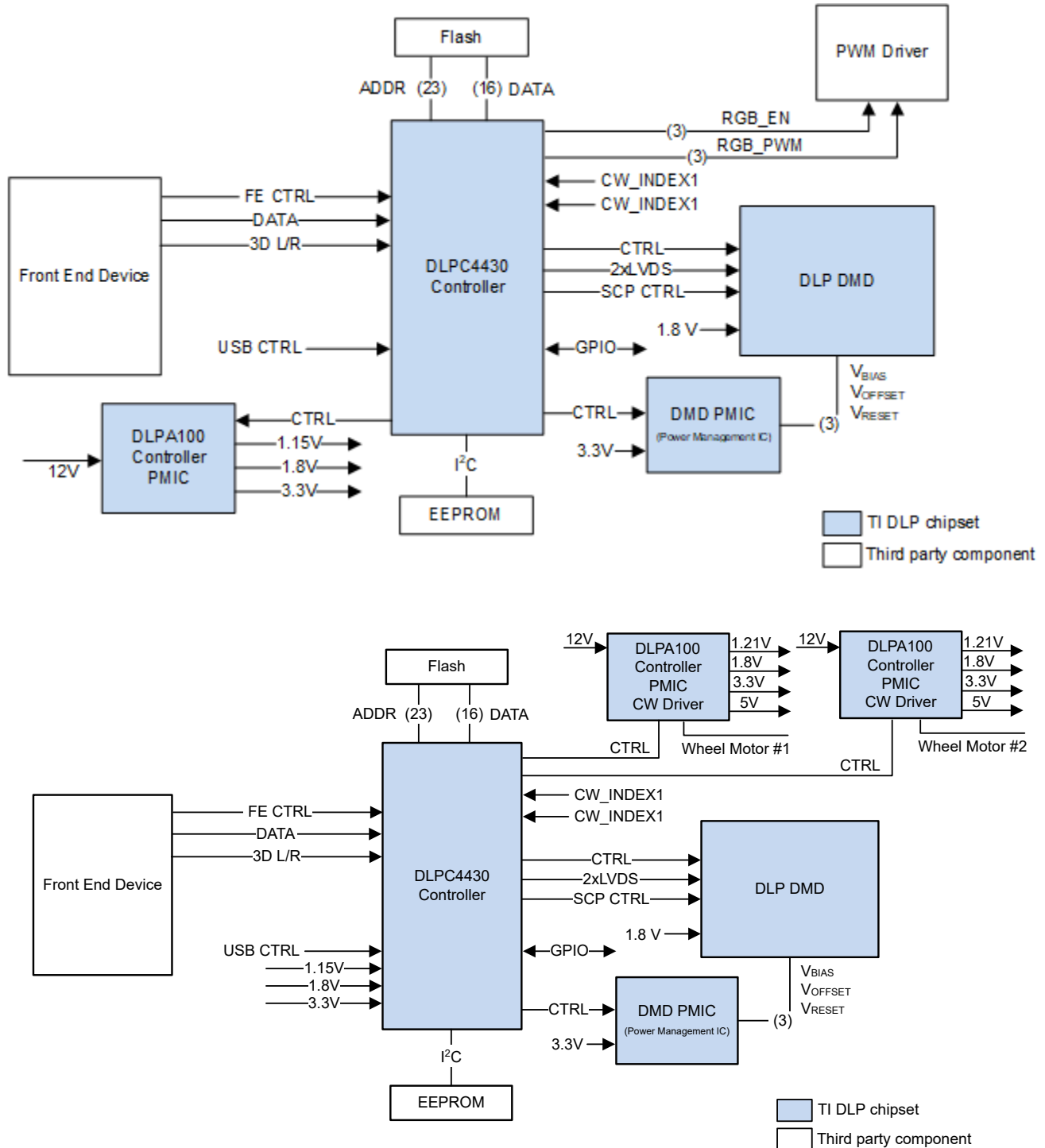


Figure 7-1. Typical DLPC4430 Application (LED, Top; LPCW, Bottom)

2.1 Design Requirements

A DLP650NE projection system is created by using the DMD chipset, including the DLP650NE, DLPC4420, and DLPA100. The DLP650NE DMD is the core imaging device in the display system and contains a 0.65-inch array of micromirrors. The DLPC4420 controller is the digital interface between the DMD and the rest of the system, taking digital input from a frontend receiver that converts the data from the source and using the converted

data for driving the DMD over an LVDS interface. The DLPA100 power management device provides voltage regulators for the DMD, controller, and illumination functionality.

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 illumination source options include lamp, LED, laser, or laser phosphor. The type of illumination used and desired brightness affect the overall system design and size.

2.2 Detailed Design Procedure

For a complete DLP system, an optical module or light engine is required that contains the DLP650NE DMD, associated illumination sources, optical elements, and necessary mechanical components.

To ensure reliable operation, the DLP650NE DMD must always be used with the DLPC4420 display controllers and a DLPA100 PMIC driver.

7 Power Supply Requirements

7.1 DMD Power Supply Requirements

The following power supplies are all required to operate the DMD: VCC, VCCI, VOFFSET, VBIAS, and VRESET. VSS must also be connected. DMD power-up and power-down sequencing is strictly controlled by the DLPC4420 device.

CAUTION

For reliable operation of the DMD, the following power supply sequencing requirements must be followed. Failure to adhere to the prescribed power-up and power-down procedures may affect device reliability. VCC, VCCI, VOFFSET, VBIAS, and VRESET power supplies have to be coordinated during power-up and power-down operations. VSS must also be connected. Failure to meet any of the below requirements results in a significant reduction in the DMD's reliability and lifetime. Refer to [Figure 7-1](#).

7.2 DMD Power Supply Power-Up Procedure

- During power-up, VCC and VCCI must always start and settle before VOFFSET, VBIAS, and VRESET voltages are applied to the DMD.
- During power-up, it is a strict requirement that the change between VBIAS and VOFFSET must be within the specified limit shown in [Recommended Operating Conditions](#). During power-up, VBIAS does not have to start after VOFFSET.
- During power-up, there is no requirement for the relative timing of VRESET with respect to VOFFSET and VBIAS.
- Power supply slew rates during power-up are flexible, provided that the transient voltage levels follow the requirements listed in the [Absolute Maximum Ratings](#) table, in the [Recommended Operating Conditions](#) table, and in the [DMD Power Supply Sequencing Requirements](#) section.
- During power-up, LVCMOS input pins must not be driven high until after VCC and VCCI have settled at operating voltages listed in the [Recommended Operating Conditions](#) table.

7.3 DMD Power Supply Power-Down Procedure

- During power-down, VCC and VCCI must be supplied until after VBIAS, VRESET, and VOFFSET are discharged to within the specified limit of ground. Refer to [Table 7-1](#).
- During power-down, it is a strict requirement that the change between VBIAS and VOFFSET must be within the specified limit shown in the [Recommended Operating Conditions](#) table. During power-down, it is not mandatory to stop driving VBIAS prior to VOFFSET.
- During power-down, there is no requirement for the relative timing of VRESET with respect to VOFFSET and VBIAS.
- Power supply slew rates during power-down are flexible, provided that the transient voltage levels follow the requirements listed in [Absolute Maximum Ratings](#), in [Recommended Operating Conditions](#), and in [Figure 7-1](#).
- During power-down, LVCMOS input pins must be less than specified in the [Recommended Operating Conditions](#) table.

EN_BIAS, EN_OFFSET, and EN_RESET are disabled by DLP controller software or PWRDNZ signal control → **Note 3**

VBIAS, VOFFSET, and VRESET are disabled by DLP controller software →

Power Off →

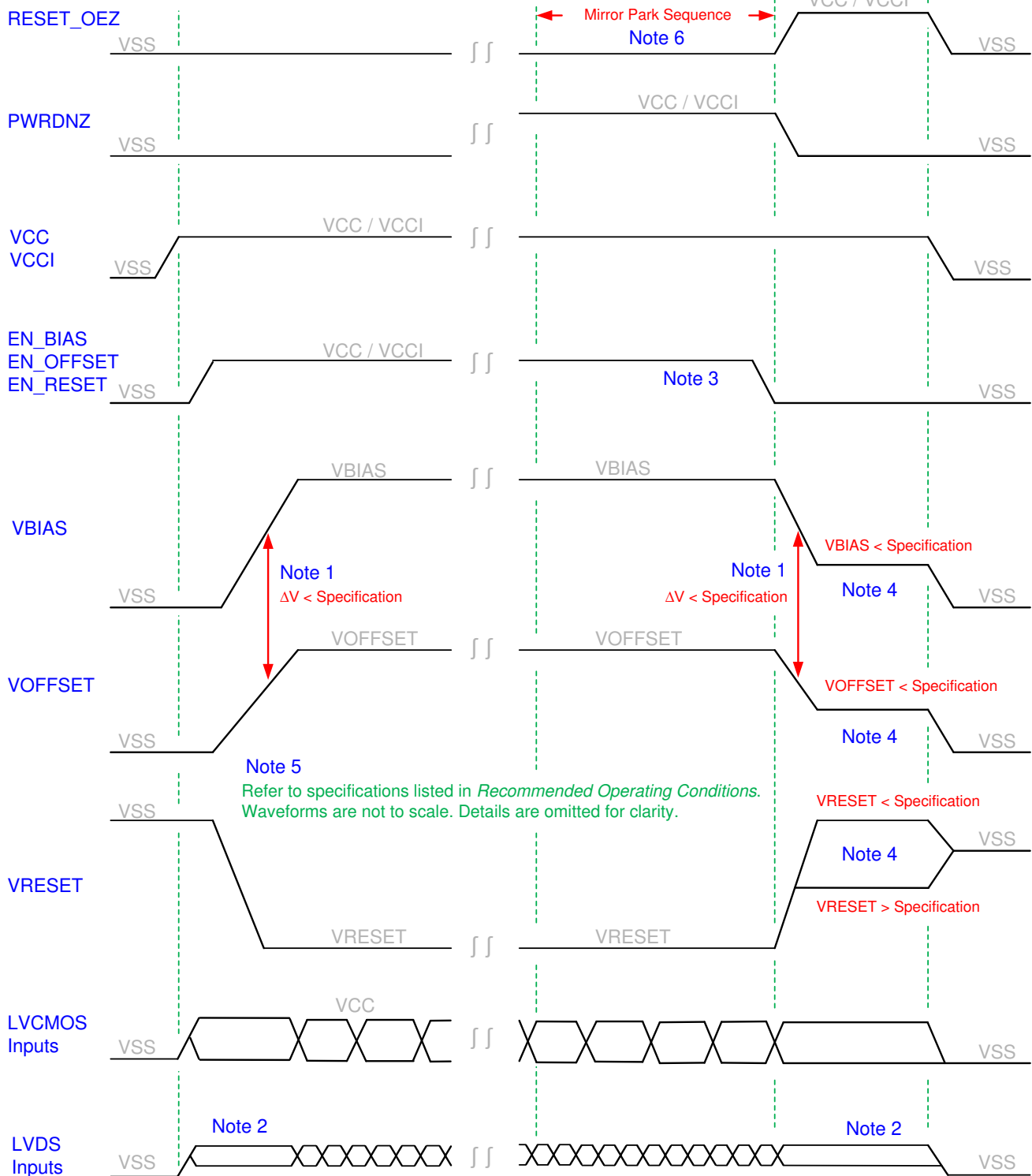


Figure 7-1. DMD Power Supply Sequencing Requirements

- A. To prevent excess current, the supply voltage change $|V_{\text{BIAS}} - V_{\text{OFFSET}}|$ must be less than specified in the [Recommended Operating Conditions](#) table. OEMs may find that the most reliable way to ensure this is to power VOFFSET prior to VBIAS during power-up and to remove VBIAS prior to VOFFSET during power-down.

- B. LVDS signals are less than the input differential voltage (VID) maximum specified in the [Recommended Operating Conditions](#) table. During power-down, LVDS signals are less than the high level input voltage (VIH) maximum specified in the [Recommended Operating Conditions](#) table.
- C. When system power is interrupted, the DLP DLPC4420 initiates a hardware power-down that activates PWRDNZ and disables VBIAS, VRESET, and VOFFSET after the micromirror park sequence. Software power-down disables VBIAS, VRESET, and VOFFSET after the micromirror park sequence through software control. For either case, enable signals EN_BIAS, EN_OFFSET, and EN_RESET are used to disable VBIAS, VOFFSET, and VRESET, respectively.
- D. Refer to [Table 7-1](#).
- E. Figure not to scale. Details have been omitted for clarity. Refer to the [Recommended Operating Conditions](#) table.
- F. EN_BIAS, EN_OFFSET, and EN_RESET are disabled by DLP controller software or PWRDNZ signal control.
- G. VBIAS, VOFFSET, and VRESET are disabled by DLP controller software.

Table 7-1. DMD Power-Down Sequence Requirements

PARAMETER		MIN	MAX	UNIT
VBIAS	Supply voltage level during power-down sequence		4.0	V
VOFFSET			4.0	V
VRESET		–4.0	0.5	V

8 Device Documentation Support

8.1 Third-Party Products Disclaimer

TI'S PUBLICATION OF INFORMATION REGARDING THIRD-PARTY PRODUCTS OR SERVICES DOES NOT CONSTITUTE AN ENDORSEMENT REGARDING THE SUITABILITY OF SUCH PRODUCTS OR SERVICES OR A WARRANTY, REPRESENTATION OR ENDORSEMENT OF SUCH PRODUCTS OR SERVICES, EITHER ALONE OR IN COMBINATION WITH ANY TI PRODUCT OR SERVICE.

8.2 Device Support

8.2.1 Device Nomenclature

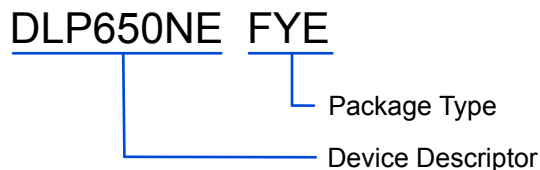


Figure 8-1. Device Number Description

8.2.2 Device Markings

The device marking will include both human-readable information and a 2-dimensional matrix code. The human-readable information is described in [Figure 8-2](#). The 2-dimensional matrix code is an alpha-numeric character string that contains the DMD part number, Part 1 of Serial Number, and Part 2 of Serial Number. The first character of the DMD Serial Number (part 1) is the manufacturing year. The second character of the DMD Serial Number (part 1) is the manufacturing month. The last character of the DMD Serial Number (part 2) is the bias voltage bin letter.

Examples: *1910-623AE GHXXXXX LLLLLLM

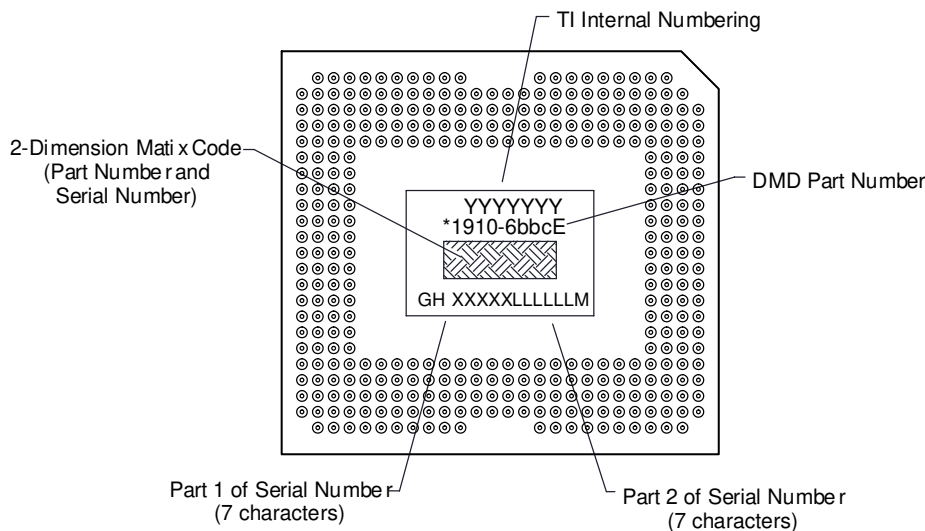


Figure 8-2. DMD Marking

8.3 Documentation Support

8.3.1 Related Documentation

The following documents contain additional information related to the use of the DLP650NE device.

- [DLPC4420 controller](#)
- [DLPC4430 controller](#)
- [TPS65145 Triple output LCD Supply with Linear Regulator and Power Good](#)
- [DLPA100 Power Management and Motor Driver](#)

8.4 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on *Alert me* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

8.5 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](#).

8.6 Trademarks

TI E2E™ is a trademark of Texas Instruments.

DLP® is a registered trademark of Texas Instruments.

All trademarks are the property of their respective owners.

8.7 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.

8.8 Glossary

[TI Glossary](#) This glossary lists and explains terms, acronyms, and definitions.

9 Revision History

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

Changes from Revision A (February 2023) to Revision B (January 2025)	Page
• Updated the controller to DLPC4420.....	1
• Added sections SOLID STATE ILLUMINATION and LAMP ILLUMINATION to Recommended Operating Conditions table.....	11
• Expanded and updated table Micromirror Array Optical Characteristics.....	21
• Updated controller to DLPC4420.....	23
• Changed to DLPC4420 Display Controller.....	25
• Updated Micromirror Array Temperature Calculation.....	26
• Updated controller to DLPC4420.....	32
• Updated controller to DLPC4420.....	33
• Updated controller to DLPC4420.....	34
• Updated controller to DLPC4420.....	35
• Updated controller to DLPC4420.....	35
• Updated device nomenclature and markings.....	38

• Added the DLPC4420 controller and link to data sheet.....	39
• Removed link to DMD101.....	39

Changes from Revision * (August 2017) to Revision A (February 2023)	Page
• This document is updated per the latest Texas Instruments and industry data sheet standards. Updated the controller to DLPC4430. Updated the links to chipset components.....	1
• Updated the controller to DLPC4430.....	1
• Added typical values to I_{OFFSET} , I_{BIAS} , and I_{RESET} currents. Removed DLPA4000, not supported.....	14
• Updated controller to DLPC4430.....	23
• Changed device supported modes for technical accuracy.....	25
• Updated <i>DMD Thermal Test Points</i> illustration.....	26
• Added section Micromirror Power Density Calculation.....	27
• Updated controller to DLPC4430.....	29
• Removed DLPA4000, not supported as PMIC. Added a table with additional legacy device information and referenced the mechanical ICD.....	32
• Updated controller to DLPC4430.....	32
• Updated <i>Typical DLPC4430 Application</i> schematic.....	33
• Updated controller to DLPC4430.....	35
• Updated controller to DLPC4430.....	35
• Updated the controller to DLPC4430 and the related documentation.....	39

10 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.

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package Pins	Package qty Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
DLP650NEFYE	Active	Production	CPGA (FYE) 350	21 JEDEC TRAY (5+1)	Yes	NIPDAU	N/A for Pkg Type	0 to 70	
DLP650NEFYE.B	Active	Production	CPGA (FYE) 350	21 JEDEC TRAY (5+1)	Yes	NIPDAU	N/A for Pkg Type	0 to 70	

⁽¹⁾ **Status:** For more details on status, see our [product life cycle](#).

⁽²⁾ **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

⁽³⁾ **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

⁽⁴⁾ **Lead finish/Ball material:** Parts 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.

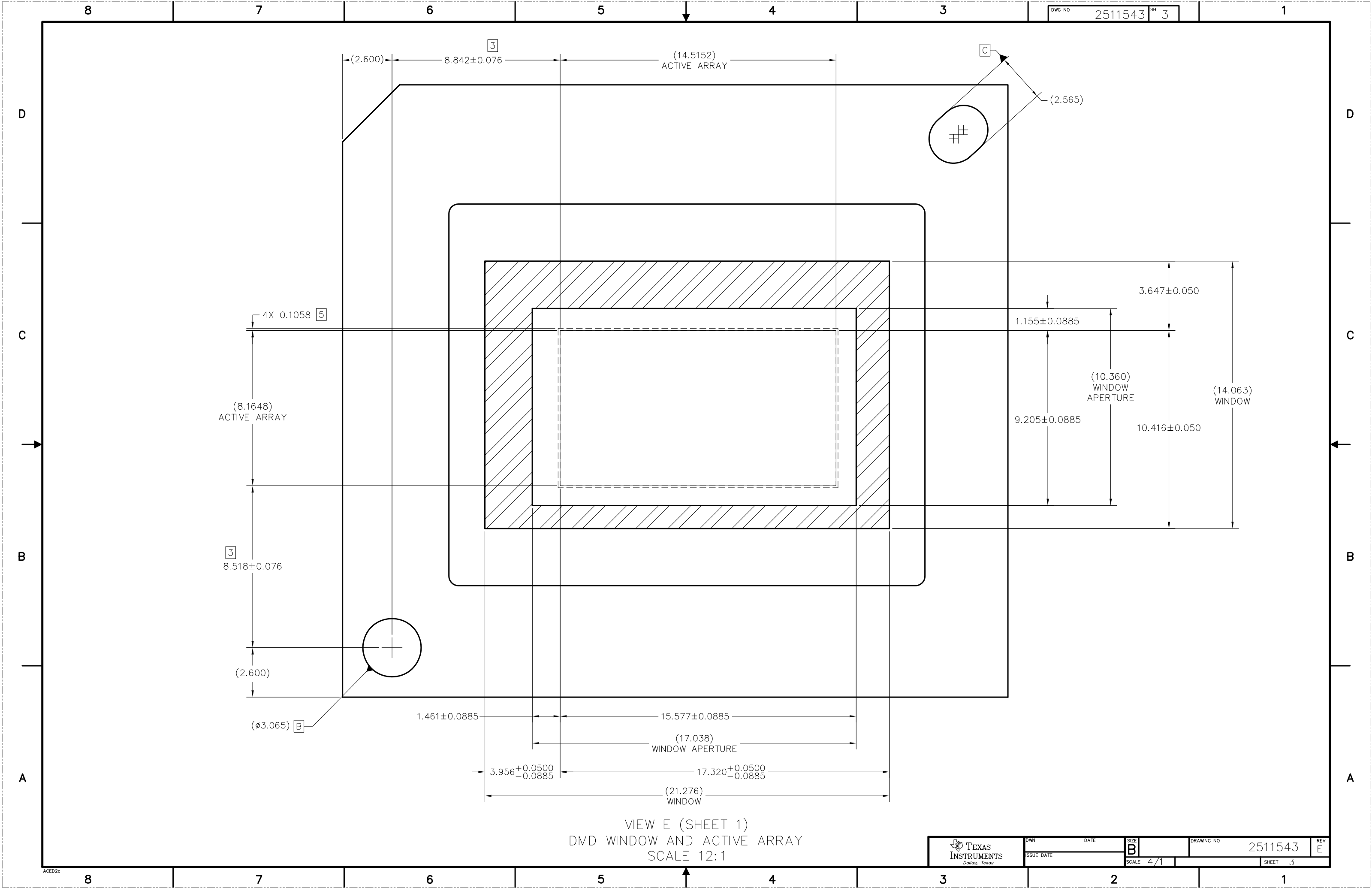
⁽⁵⁾ **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

⁽⁶⁾ **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "-" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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 TEXAS INSTRUMENTS <i>Dallas, Texas</i>	DWN	DATE	SIZE	DRAWING NO	2511543	REV	E
	ISSUE DATE		SCALE 4/1				

8

7

6

5

4

3

DWG NO

2511543

SH

4

1

D

D

C

C

B

B

A

A

3 PLACES INDICATED

A

D

DATUM PLANE 'E'

 10.000 ± 0.250 11.100 ± 0.250 350X $\phi 0.305 \pm 0.05$
 -0.025 PINS

$\phi 0.500$	D	E	F
$\phi 0.250$	D		

4 SYMBOLIZATION PAD

423

423

 (35.000) $25 \times 1.270 = 31.750$

15.875

DATUM PLANE 'F'

(PINS A1, A2, A12, A13, A14,
A15, A26, B1, AA1, AA12, AA13,
AA14, AA15, AA26 OMITTED)

A

B

C

D

E

F

G

H

J

K

L

M

N

P

R

T

U

V

W

X

Y

Z

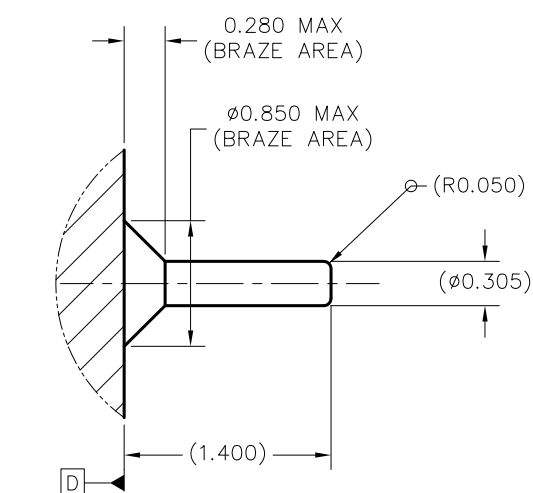
AA

 $22 \times 1.270 = 27.940$

13.970

 (2.130) (32.200)

E

VIEW F-F (SHEET 1)
PINS AND SYMBOLIZATION PAD
SCALE 8/1DETAIL G (350 PLACES)
PIN & BRAZE DIMENSIONS
SCALE 40/1

DWN DATE

ISSUE DATE

SIZE

B

SCALE 4/1

DRAWING NO

2511543

REV

E

SHEET 4

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