

## VGA Port Companion Circuit

### Features

- Includes ESD protection, level-shifting, buffering and sync impedance matching
- 7 channels of ESD protection for all VGA port connector pins meeting IEC-61000-4-2 Level 4 ESD requirements ( $\pm 8\text{kV}$  contact discharge)
- Very low loading capacitance from ESD protection diodes on VIDEO lines, 4pF maximum
- 5V drivers for HSYNC and VSYNC lines
- Integrated impedance matching resistors on sync lines
- Bi-directional level shifting N-channel FETs provided for DDC\_CLK & DDC\_DATA channels
- Backdrive protection on DDC lines
- Compact 16-lead QSOP package

### Applications

- VGA and DVI-I ports in:
  - Desktop and Notebook PCs
  - Graphics Cards
  - Set Top Boxes

### Product Description

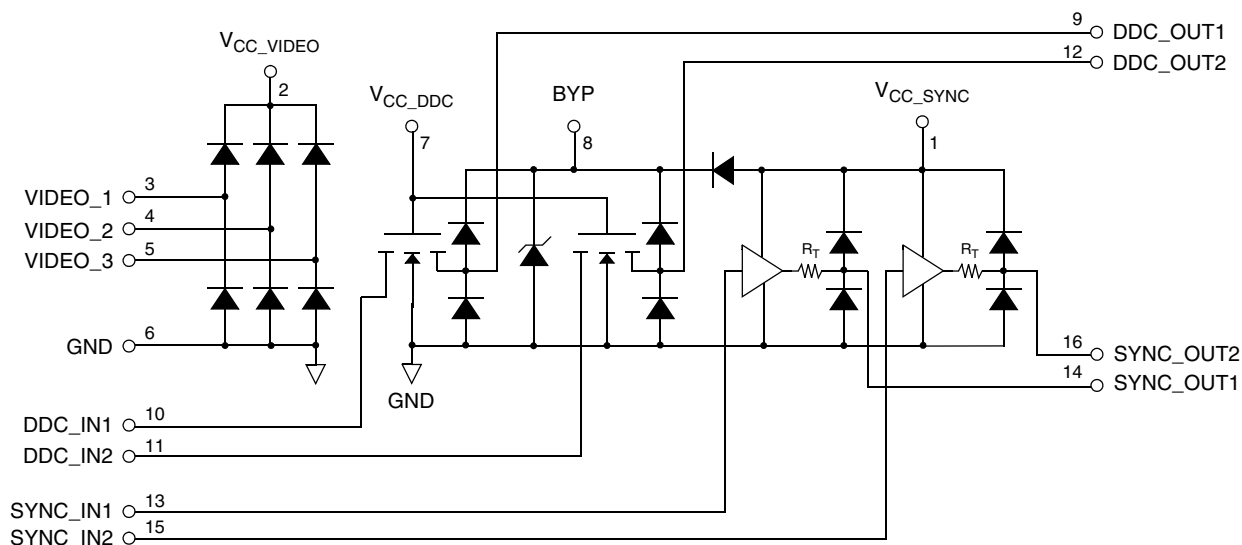
The CM2009 connects between a video graphics controller embedded in a PC, graphics adapter card or set top box and the VGA or DVI-I port connector. The CM2009 incorporates ESD protection for all signals, level shifting for the DDC signals and buffering for the SYNC signals. ESD protection for the video, DDC and SYNC lines is implemented with low-capacitance current steering diodes.

All ESD diodes are designed to safely handle the high current spikes specified by IEC-61000-4-2 Level 4 ( $\pm 8\text{kV}$  contact discharge if  $C_{BYP}$  is present,  $\pm 4\text{kV}$  if not). The ESD protection for the DDC signal pins are designed to prevent "back current" when the device is powered down while connected to a monitor that is powered up.

Separate positive supply rails are provided for the VIDEO, DDC and SYNC channels to facilitate interfacing with low voltage video controller ICs to provide design flexibility in multi-supply-voltage environments.

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### Simplified Electrical Schematic

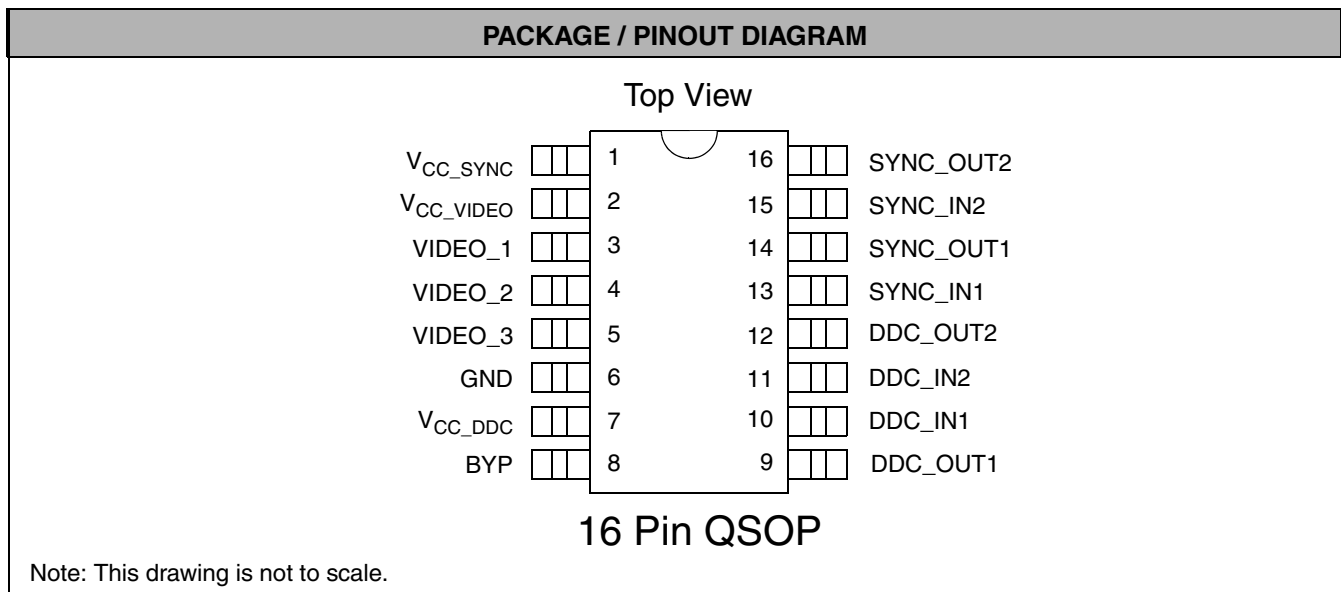


**Product Description (cont'd)**

Two non-inverting drivers provide buffering for the HSYNC and VSYNC signals from the video controller IC (SYNC1, SYNC2). These buffers accept TTL input levels and convert them to CMOS output levels that swing between Ground and  $V_{CC\_SYNC}$ , which is typically 5V. Additionally, each driver has a series termination resistor ( $R_T$ ) connected to the SYNC\_OUT pin, eliminating the external termination resistors typically required for the HSYNC and VSYNC lines of the video cable. There are three versions with different values of  $R_T$  to allow termination at typically 65Ω (CM2009-00) or 55Ω (CM2009-01) or 15Ω (CM2009-02).

The 15Ω (CM2009-02) version will typically require two external resistors which can be chosen to exactly match the characteristic impedance of the SYNC lines of the video cable.

Two N-channel MOSFETs provide the level shifting function required when the DDC controller is operated at a lower supply voltage than the monitor. The gate terminals for these MOSFETs ( $V_{CC\_DDC}$ ) should be connected to the supply rail (typically 3.3V) that supplies power to the transceivers of the DDC controller.



**Ordering Information**

<b>PART NUMBERING INFORMATION</b>						
$R_{OUT}$	Pins	Package	Standard Finish		Lead-free Finish	
			Ordering Part Number <sup>1</sup>	Part Marking	Ordering Part Number <sup>1</sup>	Part Marking
65Ω	16	QSOP	CM2009-00QS	CM2009-00QS	CM2009-00QR	CM2009-00QR
55Ω	16	QSOP	CM2009-01QS	CM2009-01QS	CM2009-01QR	CM2009-01QR
15Ω	16	QSOP	CM2009-02QS	CM2009-02QS	CM2009-02QR	CM2009-02QR

Note 1: Parts are shipped in Tape & Reel form unless otherwise specified.

## Pin Description

PIN DESCRIPTIONS		
LEAD(s)	NAME	DESCRIPTION
1	V <sub>CC_SYNC</sub>	This is an isolated supply input for the SYNC_1 and SYNC_2 level shifters and their associated ESD protection circuits.
2	V <sub>CC_VIDEO</sub>	This is a supply pin specifically for the VIDEO_1, VIDEO_2 and VIDEO_3 ESD protection circuits.
3	VIDEO_1	Video signal ESD protection channel. This pin is typically tied one of the video lines between the VGA controller device and the video connector.
4	VIDEO_2	Video signal ESD protection channel. This pin is typically tied one of the video lines between the VGA controller device and the video connector.
5	VIDEO_3	Video signal ESD protection channel. This pin is typically tied one of the video lines between the VGA controller device and the video connector.
6	GND	Ground reference supply pin.
7	V <sub>CC_DDC</sub>	This is an isolated supply input for the DDC_1 and DDC_2 level-shifting N-FET gates.
8	BYP	This input is used to connect an external 0.2uF bypass capacitor to the DDC circuits, resulting in an increased ESD withstand voltage rating for these circuits ( $\pm 8kV$ with vs. $\pm 4kV$ without).
9	DDC_OUT1	DDC signal output. Connects to the video connector side of one of the sync lines.
10	DDC_IN1	DDC signal input. Connects to the VGA controller side of one of the sync lines.
11	DDC_IN2	DDC signal input. Connects to the VGA controller side of one of the sync lines.
12	DDC_OUT2	DDC signal output. Connects to the video connector side of one of the sync lines.
13	SYNC_IN1	Sync signal buffer input. Connects to the VGA controller side of one of the sync lines.
14	SYNC_OUT1	Sync signal buffer output. Connects to the video connector side of one of the sync lines.
15	SYNC_IN2	Sync signal buffer input. Connects to the VGA controller side of one of the sync lines.
16	SYNC_OUT2	Sync signal buffer output. Connects to the video connector side of one of the sync lines.

## Specifications

ABSOLUTE MAXIMUM RATINGS		
PARAMETER	RATING	UNITS
V <sub>CC_VIDEO</sub> , V <sub>CC_DDC</sub> and V <sub>CC_SYNC</sub> Supply Voltage Inputs	[GND - 0.5] to +6.0	V
ESD Diode Forward Current (one diode conducting at a time)	10	mA
DC Voltage at Inputs VIDEO_1, VIDEO_2, VIDEO_3	[GND - 0.5] to [V <sub>CC_VIDEO</sub> + 0.5]	V
DDC_IN1, DDC_IN2	[GND - 0.5] to 6.0	V
DDC_OUT1, DDC_OUT2	[GND - 0.5] to 6.0	V
SYNC_IN1, SYNC_IN2	[GND - 0.5] to [V <sub>CC_SYNC</sub> + 0.5]	V
Operating Temperature Range	-40 to +85	°C
Storage Temperature Range	-40 to +150	°C
Package Power Rating (T <sub>A</sub> =25°C)	500	mW

## Specifications (cont'd)

ELECTRICAL OPERATING CHARACTERISTICS (SEE NOTE 1)						
SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
$I_{CC\_VIDEO}$	$V_{CC\_VIDEO}$ Supply Current	$V_{CC\_VIDEO} = 5.0V$ ; VIDEO inputs at $V_{CC\_VIDEO}$ or GND			10	$\mu A$
$I_{CC\_DDC}$	$V_{CC\_DDC}$ Supply Current	$V_{CC\_DDC} = 5.0V$			10	$\mu A$
$I_{CC\_SYNC}$	$V_{CC\_SYNC}$ Supply Current	$V_{CC\_SYNC} = 5V$ ; SYNC inputs at GND or $V_{CC\_SYNC}$ ; SYNC outputs unloaded			50	$\mu A$
		$V_{CC\_SYNC} = 5V$ ; SYNC inputs at 3.0V; SYNC outputs unloaded			2.0	mA
$V_F$	ESD Diode Forward Voltage	$I_F = 10mA$			1.0	V
$V_{IH}$	Logic High Input Voltage	$V_{CC\_SYNC} = 5.0V$ ; Note 2	2.0			V
$V_{IL}$	Logic Low Input Voltage	$V_{CC\_SYNC} = 5.0V$ ; Note 2			0.6	V
$V_{OH}$	Logic High Output Voltage	$I_{OH} = 0mA$ , $V_{CC\_SYNC} = 5.0V$ ; Note 2	4.85			V
$V_{OL}$	Logic Low Output Voltage	$I_{OL} = 0mA$ , $V_{CC\_SYNC} = 5.0V$ ; Note 2			0.15	V
$R_{OUT}$	SYNC Driver Output Resistance (CM2009-00 only)	$V_{CC\_SYNC} = 5.0V$ ; SYNC Inputs at GND or 3.0V		65		$\Omega$
$R_{OUT}$	SYNC Driver Output Resistance (CM2009-01 only)	$V_{CC\_SYNC} = 5.0V$ ; SYNC Inputs at GND or 3.0V		55		$\Omega$
$R_{OUT}$	SYNC Driver Output Resistance (CM2009-02 only)	$V_{CC\_SYNC} = 5.0V$ ; SYNC Inputs at GND or 3.0V; Note 5		15		$\Omega$
$V_{OH-02}$	Logic High Output Voltage (CM2009-02 only)	$I_{OH} = 24mA$ ; $V_{CC\_SYNC} = 5.0V$ ; Note 2	2.0			V
$V_{OL-02}$	Logic Low Output Voltage (CM2009-02 only)	$I_{OL} = 24mA$ ; $V_{CC\_SYNC} = 5.0V$ ; Note 2			0.8	V
$I_{IN}$	Input Current VIDEO Inputs	$V_{CC\_VIDEO} = 5.0V$ ; $V_{IN} = V_{CC\_VIDEO}$ or GND			$\pm 1$	$\mu A$
	SYNC_IN1, SYNC_IN2 Inputs	$V_{CC\_SYNC} = 5.0V$ ; $V_{IN} = V_{CC\_SYNC}$ or GND			$\pm 1$	$\mu A$
$I_{OFF}$	Level Shifting N-MOSFET "OFF" State Leakage Current	$(V_{CC\_DDC} - V_{DDC\_IN}) \leq 0.4V$ ; $V_{DDC\_OUT} = V_{CC\_DDC}$			10	$\mu A$
		$(V_{CC\_DDC} - V_{DDC\_OUT}) \leq 0.4V$ ; $V_{DDC\_IN} = V_{CC\_DDC}$			10	$\mu A$
$V_{ON}$	Voltage Drop Across Level-shifting N-MOSFET when "ON"	$V_{CC\_DDC} = 2.5V$ ; $V_S = GND$ ; $I_{DS} = 3mA$ ;			0.18	V
$C_{IN\_VID}$	VIDEO Input Capacitance	$V_{CC\_VIDEO} = 5.0V$ ; $V_{IN} = 2.5V$ ; $f = 1MHz$ ; Note 4			4	pF
		$V_{CC\_VIDEO} = 2.5V$ ; $V_{IN} = 1.25V$ ; $f = 1MHz$ ; Note 4			4.5	pF
$t_{PLH}$	SYNC Driver L => H Propagation Delay	$C_L = 50pF$ ; $V_{CC} = 5.0V$ ; Input $t_R$ and $t_F \leq 5ns$			12	ns
$t_{PHL}$	SYNC Driver H => L Propagation Delay	$C_L = 50pF$ ; $V_{CC} = 5.0V$ ; Input $t_R$ and $t_F \leq 5ns$			12	ns
$t_R, t_F$	SYNC Driver Output Rise & Fall Times	$C_L = 50pF$ ; $V_{CC} = 5.0V$ ; Input $t_R$ and $t_F \leq 5ns$		4		ns
$V_{ESD}$	ESD Withstand Voltage	$V_{CC\_VIDEO} = V_{CC\_SYNC} = 5V$ ; Notes 3, 4 & 5	$\pm 8$			kV

Note 1: All parameters specified over standard operating conditions unless otherwise noted.

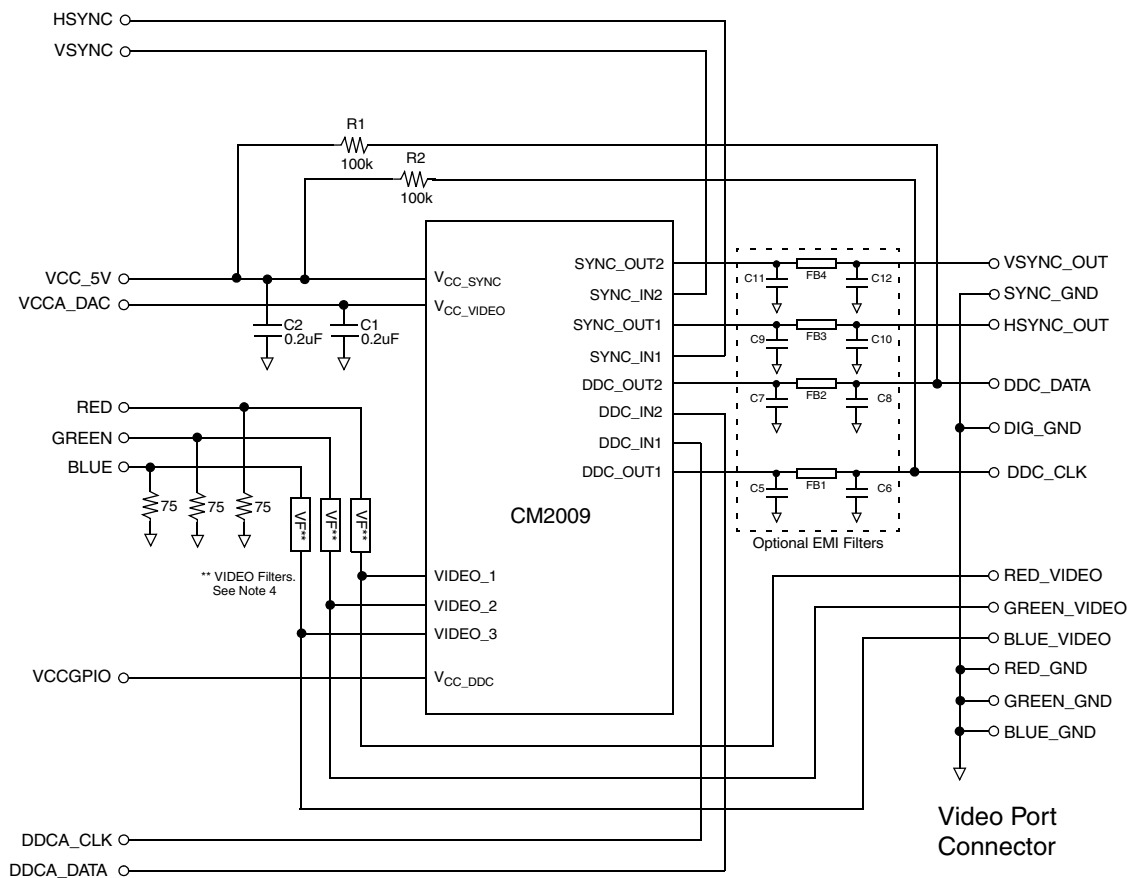
Note 2: These parameters apply only to the SYNC drivers. Note that  $R_{OUT} = R_T + R_{BUFFER}$ .

Note 3: Per the IEC-61000-4-2 International ESD Standard, Level 4 contact discharge method. BYP,  $V_{CC\_VIDEO}$  and  $V_{CC\_SYNC}$  must be bypassed to GND via a low impedance ground plane with a 0.2 $\mu F$ , low inductance, chip ceramic capacitor at each supply pin. ESD pulse is applied between the applicable pins and GND. ESD pulses can be positive or negative with respect to GND. Applicable pins are: VIDEO\_1, VIDEO\_2, VIDEO\_3, SYNC\_OUT1, SYNC\_OUT2, DDC\_OUT1 and DDC\_OUT2. All other pins are ESD protected to the industry standard  $\pm 2kV$  Human Body Model (MIL-STD-883, Method 3015). The bypass capacitor at the BYP pin may optionally be omitted, in which case the max. ESD withstand voltage for the DDC\_OUT1 and DDC\_OUT2 pins is reduced to  $\pm 4kV$ .

Note 4: This parameter is guaranteed by design and characterization.

Note 5: The SYNC\_OUT pins on the CM2009-02 are guaranteed for 2kV HBM ESD protection.

## Application Information



**Figure 1. Typical Application Connection Diagram**

### NOTES

- 1 The CM2009 should be placed as close to the VGA or DVI-I connector as possible.
- 2 The ESD protection channels VIDEO\_1, VIDEO\_2, VIDEO\_3 may be used interchangeably between the R, G, B signals.
- 3 If differential video signal routing is used, the RED, BLUE, and GREEN signal lines should be terminated with external 37.5 resistors.
- 4 "VF" are external video filters for the RGB signals.
- 5 Supply bypass capacitors C1 and C2 must be placed immediately adjacent to the corresponding Vcc pins. Connections to the Vcc pins and ground plane must be made with minimal length copper traces (preferably less than 5mm) for best ESD protection.
- 6 The bypass capacitor for the BYP pin has been omitted in this diagram. This results in a reduction in the maximum ESD withstand voltage at the DDC\_OUT pins from  $\pm 8\text{kV}$  to  $\pm 4\text{kV}$ . If 8kV ESD protection is required, a 0.2 $\mu\text{F}$  ceramic bypass capacitor should be connected between BYP and ground.
- 7 The SYNC buffers may be used interchangeably between HSYNC and VSYNC.
- 8 The EMI filters at the SYNC\_OUT and DDC\_OUT pins (C5 to C12, and Ferrite Beads FB1 to FB4) are for reference only. The component values and filter configuration may be changed to suit the application.
- 9 The DDC level shifters DDC\_IN, DDC\_OUT, may be used interchangeably between DDCA\_CLK and DDCA\_DATA.
- 10 R1, R2 are optional. They may be used, if required, to pull the DDC\_CLK and DDC\_DATA lines to VCC\_5V when no monitor is connected to the VGA connector. If used, it should be noted that "back current" may flow between the DDC pins and VCC\_5V via these resistors when VCC\_5V is powered down.
- 11 For optimal ESD performance with the CM2009-02, an additional clamp device (such as the CMD PACDN042) should be placed on HSYNC/VSYNC lines between the external matching resistor and the VGA connector.

## Mechanical Details

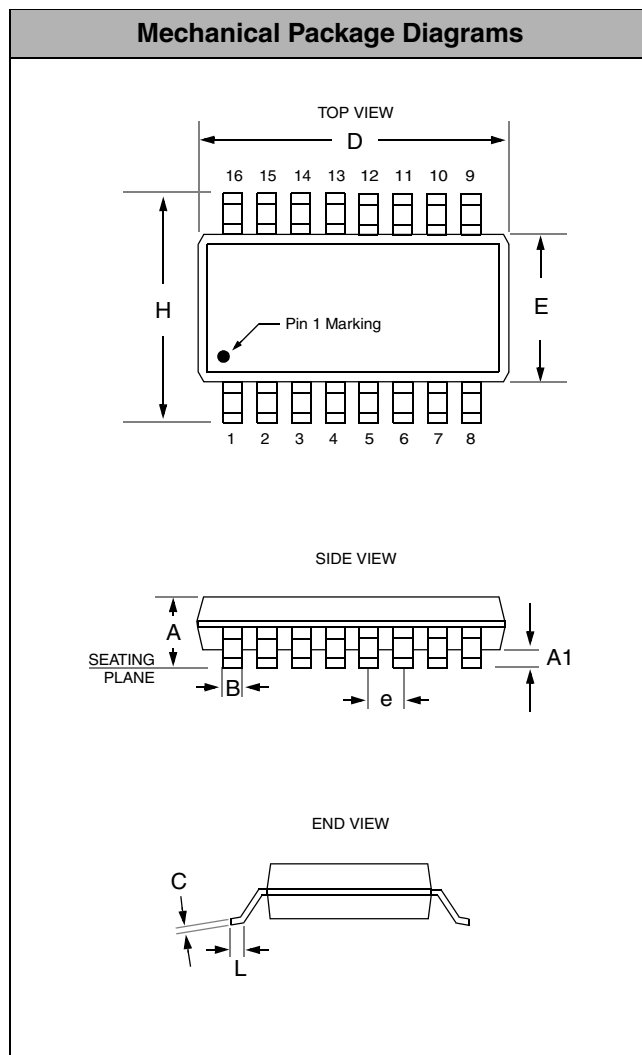
### QSOP Mechanical Specifications

CM2009 devices are packaged in 16-pin QSOP packages. Dimensions are presented below.

For complete information on the QSOP-16 package, see the California Micro Devices QSOP Package Information document.

PACKAGE DIMENSIONS				
Package	QSOP (JEDEC name is SSOP)			
Pins	16			
Dimensions	Millimeters		Inches	
	Min	Max	Min	Max
A	1.35	1.75	0.053	0.069
A1	0.10	0.25	0.004	0.010
B	0.20	0.30	0.008	0.012
C	0.18	0.25	0.007	0.010
D	4.80	5.00	0.189	0.197
E	3.81	3.98	0.150	0.157
e	0.64 BSC		0.025 BSC	
H	5.79	6.19	0.228	0.244
L	0.40	1.27	0.016	0.050
# per tube	100 pcs*			
# per tape and reel	2500 pcs			
Controlling dimension: inches				

\* This is an approximate number which may vary.



Package Dimensions for QSOP-16