



## Features

- HDMI 1.3 compliant
- Supports thin dielectric and 2-layer boards
- Minimizes TMDS skew with 0.05pF matching
- Long HDMI cable support with integrated I<sup>2</sup>C accelerator
- Active termination and slew rate limiting for CEC
- Supports direct connection to CEC microcontroller
- Integrated I<sup>2</sup>C level shifting to CMOS level including low logic level voltages
- Integrated  $\pm 8\text{kV}$  ESD protection and backdrive protection on all external I/O lines
- Supports active and passive control of hot plug detect signal
- Multiport I<sup>2</sup>C support eliminates need for analog mux on DDC lines
- Simplified layout with matched 0.5mm trace spacing
- RoHS-compliant, lead-free packaging

## Applications

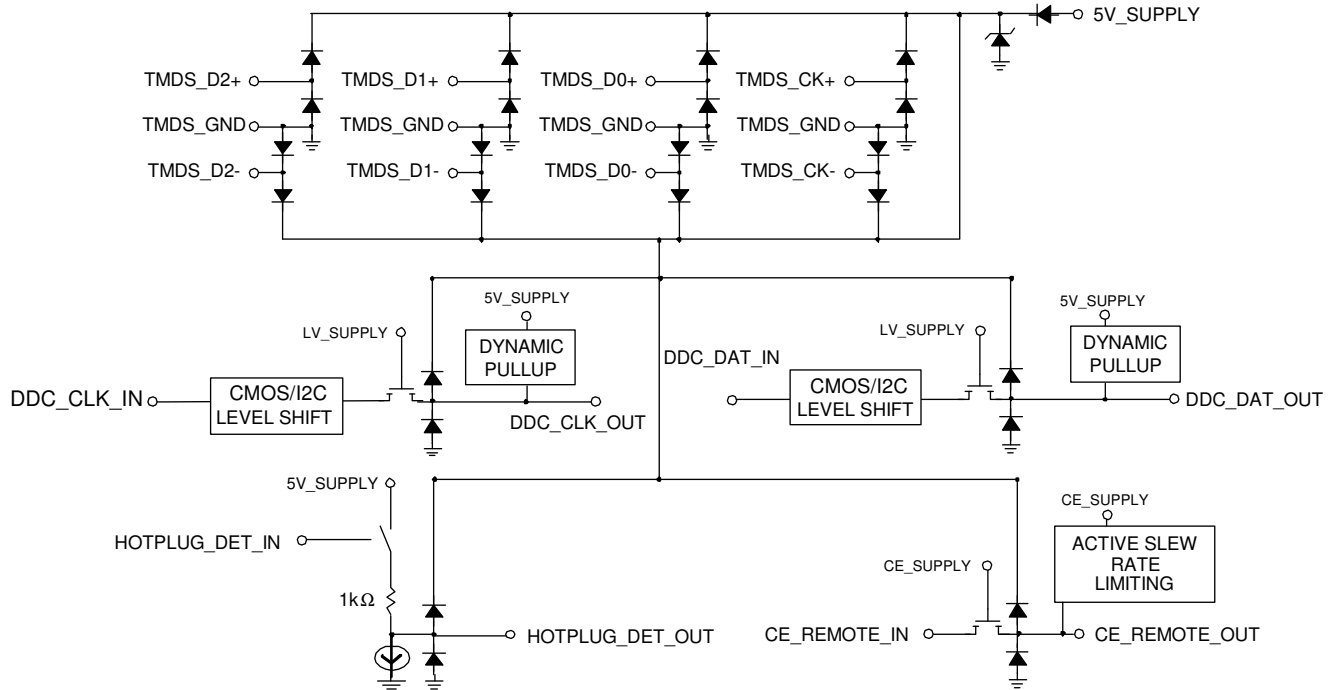
- PC and consumer electronics
- Digital TV, PC monitors and projectors

## Product Description

The CM2031 HDMI Receiver Port Protection and Interface Device is specifically designed for next generation HDMI Sink interface protection.

An integrated package provides all ESD, slew rate limiting on CEC line, level shifting/isolation and backdrive protection for an HDMI port in a single 38-Pin TSSOP package.

The CM2031 part is specifically designed to provide the designer with the most reliable path to HDMI 1.3 CTS compliance.

**Electrical Schematic****PACKAGE / PINOUT DIAGRAM****TOP VIEW**

|                |    |    |                 |
|----------------|----|----|-----------------|
| 5V_SUPPLY      | 1  | 38 | N/C             |
| LV_SUPPLY      | 2  | 37 | CE_SUPPLY       |
| GND            | 3  | 36 | GND             |
| TMDS_D2+       | 4  | 35 | TMDS_D2+        |
| TMDS_GND       | 5  | 34 | TMDS_GND        |
| TMDS_D2-       | 6  | 33 | TMDS_D2-        |
| TMDS_D1+       | 7  | 32 | TMDS_D1+        |
| TMDS_GND       | 8  | 31 | TMDS_GND        |
| TMDS_D1-       | 9  | 30 | TMDS_D1-        |
| TMDS_D0+       | 10 | 29 | TMDS_D0+        |
| TMDS_GND       | 11 | 28 | TMDS_GND        |
| TMDS_D0-       | 12 | 27 | TMDS_D0-        |
| TMDS_CK+       | 13 | 26 | TMDS_CK+        |
| TMDS_GND       | 14 | 25 | TMDS_GND        |
| TMDS_CK-       | 15 | 24 | TMDS_CK-        |
| CE_REMOTE_IN   | 16 | 23 | CE_REMOTE_OUT   |
| DDC_CLK_IN     | 17 | 22 | DDC_CLK_OUT     |
| DDC_DAT_IN     | 18 | 21 | DDC_DAT_OUT     |
| HOTPLUG_DET_IN | 19 | 20 | HOTPLUG_DET_OUT |

Note: This drawing is not to scale.

**38-PIN TSSOP PACKAGE**

| PIN DESCRIPTIONS                          |                 |                    |                                                                                                                               |
|-------------------------------------------|-----------------|--------------------|-------------------------------------------------------------------------------------------------------------------------------|
| PINS                                      | NAME            | ESD Level          | DESCRIPTION                                                                                                                   |
| 4, 35                                     | TMDS_D2+        | 8kV <sup>3</sup>   | TMDS 0.9pF ESD protection. <sup>1</sup>                                                                                       |
| 6, 33                                     | TMDS_D2–        | 8kV <sup>3</sup>   | TMDS 0.9pF ESD protection. <sup>1</sup>                                                                                       |
| 7, 32                                     | TMDS_D1+        | 8kV <sup>3</sup>   | TMDS 0.9pF ESD protection. <sup>1</sup>                                                                                       |
| 9, 30                                     | TMDS_D1–        | 8kV <sup>3</sup>   | TMDS 0.9pF ESD protection. <sup>1</sup>                                                                                       |
| 10, 29                                    | TMDS_D0+        | 8kV <sup>3</sup>   | TMDS 0.9pF ESD protection. <sup>1</sup>                                                                                       |
| 12, 27                                    | TMDS_D0–        | 8kV <sup>3</sup>   | TMDS 0.9pF ESD protection. <sup>1</sup>                                                                                       |
| 13, 26                                    | TMDS_CK+        | 8kV <sup>3</sup>   | TMDS 0.9pF ESD protection. <sup>1</sup>                                                                                       |
| 15, 24                                    | TMDS_CK–        | 8kV <sup>3</sup>   | TMDS 0.9pF ESD protection. <sup>1</sup>                                                                                       |
| 16                                        | CE_REMOTE_IN    | 2kV <sup>4</sup>   | CE_SUPPLY referenced logic level in.                                                                                          |
| 23                                        | CE_REMOTE_OUT   | 8kV <sup>3</sup>   | 5V_SUPPLY referenced logic level out plus 10pF ESD.                                                                           |
| 17                                        | DDC_CLK_IN      | 2kV <sup>4</sup>   | LV_SUPPLY referenced logic level in.                                                                                          |
| 22                                        | DDC_CLK_OUT     | 8kV <sup>3</sup>   | 5V_SUPPLY referenced logic level out plus 10pF ESD.                                                                           |
| 18                                        | DDC_DAT_IN      | 2kV <sup>4</sup>   | LV_SUPPLY referenced logic level in.                                                                                          |
| 21                                        | DDC_DAT_OUT     | 8kV <sup>3</sup>   | 5V_SUPPLY referenced logic level out plus 10pF ESD.                                                                           |
| 19                                        | HOTPLUG_DET_IN  | 2kV <sup>4</sup>   | LV_SUPPLY referenced logic level in.                                                                                          |
| 20                                        | HOTPLUG_DET_OUT | 8kV <sup>3</sup>   | 5V_SUPPLY referenced logic level out plus 10pF ESD. A 0.1μF bypass ceramic capacitor is recommended on this pin. <sup>2</sup> |
| 2                                         | LV_SUPPLY       | 2kV <sup>4</sup>   | Bias for CE / DDC / HOTPLUG level shifters.                                                                                   |
| 37                                        | CE_SUPPLY       | 2kV <sup>4,2</sup> | CEC bias voltage. Previously CM2020 ESD_BYN pin.                                                                              |
| 1                                         | 5V_SUPPLY       | 2kV <sup>4</sup>   | Current source for 5V_OUT, VREF for DDC I <sup>2</sup> C voltage references, and bias for 8kV ESD pins.                       |
| 38                                        | N/C             | N/A                | N/C                                                                                                                           |
| 3, 5, 8, 11,<br>14, 25,<br>28, 31, 34, 36 | GND / TMDS_GND  | N/A                | GND reference.                                                                                                                |

Note 1: These 2 pins need to be connected together in-line on the PCB. See recommended layout diagram.

Note 2: This output can be connected to an external 0.1μF ceramic capacitor/pads to maintain backward compatibility with the CM2020.

Note 3: Standard IEC 61000-4-2, C<sub>DISCHARGE</sub>=150pF, R<sub>DISCHARGE</sub>=330Ω, 5V\_SUPPLY and LV\_SUPPLY within recommended operating conditions, GND=0V, 5V\_OUT (pin 38), and HOTPLUG\_DET\_OUT (pin 20) each bypassed with a 0.1μF ceramic capacitor connected to GND.

Note 4: Human Body Model per MIL-STD-883, Method 3015, C<sub>DISCHARGE</sub>=100pF, R<sub>DISCHARGE</sub>=1.5kΩ, 5V\_SUPPLY and LV\_SUPPLY within recommended operating conditions, GND=0V, 5V\_OUT (pin 38), and HOTPLUG\_DET\_OUT (pin 20) each bypassed with a 0.1μF ceramic capacitor connected to GND.

Note 5: These pins should be routed directly to the associated GND pins on the HDMI connector with single point ground vias at the connector

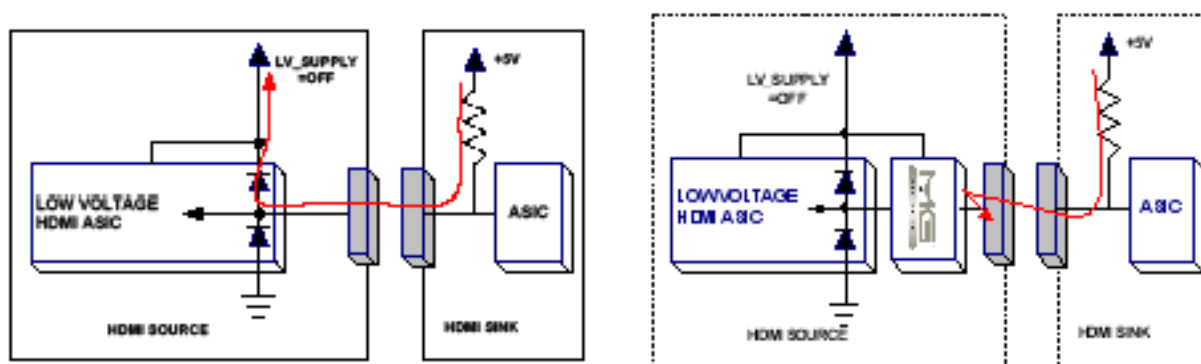
## Backdrive Protection and Isolation

Backdrive current is defined as the undesirable current flow through an I/O pin when that I/O pin's voltage exceeds the related local supply voltage for that circuitry. This is a potentially common occurrence in multimedia entertainment systems with multiple components and several power plane domains in each system.

For example, if a DVD player is switched off and an HDMI connected TV is powered on, there is a possibility of reverse current flow back into the main power supply rail of the DVD player from pull-ups in the TV. As little as a few milliamps of backdrive current flowing back into the power rail can charge the DVD player's bulk bypass capacitance on the power rail to some intermediate level. If this level rises above the power-on-reset (POR) voltage level of some of the integrated circuits in the DVD player, then these devices may not reset properly when the DVD player is turned back on.

If any SOC devices are incorporated in the design which have built-in level shifter and/or ESD protection structures, there can be a risk of permanent damage due to backdrive. In this case, backdrive current can forward bias the on-chip ESD protection structure. If the current flow is high enough, even as little as a few milliamps, it could destroy one of the SOC chip's internal DRC diodes, as they are not designed for passing DC.

To avoid either of these situations, the CM2031 was designed to block backdrive current, guaranteeing less than 5 $\mu$ A into any I/O pin when the I/O pin voltage exceeds its related operating CM2031 supply voltage.



**Figure 1. Backdrive Protection Diagram.**

## Display Data Channel (DDC) lines

The DDC interface is based on the I<sup>2</sup>C serial bus protocol for EDID configuration.

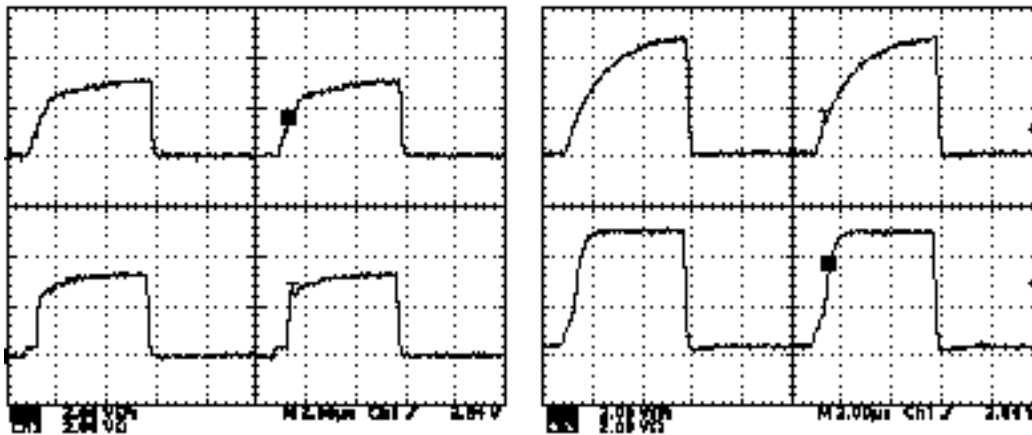
### DYNAMIC PULLUPS

Based on the HDMI specification, the maximum capacitance of the DDC line can approach 800pF (50pF from source, 50pF from sink, and 700pF from cable). At the upper range of capacitance values (i.e. long cables), it becomes impossible for the DDC lines to meet the I<sup>2</sup>C timing specifications with the minimum pull-up resistor of 1.5k  $\Omega$  (at the source).

For this reason, the CM2031 was designed with an internal I<sup>2</sup>C accelerator to meet the AC timing specification even with very long and non-compliant cables.

The internal accelerator works with the source pull-up and the local 47k $\Omega$  pullup to increase the positive slew rate of the DDC\_CLK\_OUT and DDC\_DAT\_OUT lines whenever the sensed voltage level exceeds 0.3\*5V\_SUPPLY (approximately 1.5V). This provides faster overall risetime in heavily loaded situations without overloading the multi-drop open drain I<sup>2</sup>C outputs elsewhere.

#### DYNAMIC PULLUPS (CONT'D)



**Figure 2. Dynamic DDC Pullups** (Discrete - Top, CM2031 - Bottom; 3.3V ASIC - Left, 5V Cable - Right.)

Figure 2 demonstrates the “worst case” operation of the dynamic CM2031 DDC level shifting circuitry (bottom) against a discrete NFET common-gate level shifter circuit with a typical 1.5k $\Omega$  pullup at the source (top.) Both are shown driving an off-spec, but unfortunately readily available 31m HDMI cable which exceeds the 700pF HDMI specification. Some widely available HDMI cables have been measured at *over 4nF*.

When the standard I/OD cell releases the NFET discrete shifter, the risetime is limited by the pullup and the parasitics of the cable, source and sink. For long cables, this can extend the risetime and reduce the margin for reading a valid “high” level on the data line. In this case, an HDMI source may not be able to read uncorrupted data and will not be able to initiate a link.

With the CM2031’s dynamic pullups, when the ASIC driver releases its DDC line and the “OUT” line reaches at least 0.3\*VDD (of 5V\_SUPPLY), then the “OUT” active pullups are enabled and the CM2031 takes over driving the cable until the “OUT” voltage approaches the 5V\_SUPPLY rail.

The internal pass element and the dynamic pullups also work together to damp reflections on the longer cables and keep them from glitching the local ASIC.

#### I<sup>2</sup>C LOW LEVEL SHIFTING

In addition to the Dynamic Pullups described in the previous section, then CM2031 also incorporates improved I<sup>2</sup>C low-level shifting on the DDC\_CLK\_IN and DDC\_DAT\_IN lines for enhanced compatibility.

Typical discrete NFETs level shifters can advertise specifications for low RDS[on], but usually state relatively high V[GS] test parameters, requiring a 'switch' signal (gate voltage) as high as 10V or more. At a sink current of

4mA for the ASIC on DDC\_XX\_IN, the CM2031 guarantees no more than 140mV increase to DDC\_XX\_OUT, even with a switching control of 2.5V on LV\_SUPPLY.

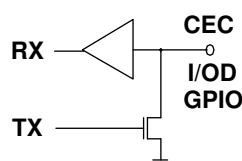
Additionally, when I<sup>2</sup>C devices are driving the external cable, an internal pulldown on DDC\_XX\_IN guarantees that the VOL seen by the ASIC on DDC\_XX\_IN is equal to or lower than DDC\_XX\_OUT.

### **Multiport DDC Multiplexing**

Additionally, by switching LV\_SUPPLY, the DDC/HPD blocks can be independently disabled by engaging their inherent “backdrive” protection. This allows N:1 multiplexing of the low-speed HDMI signals without any additional FET switches.

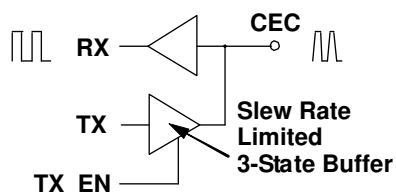
## **Consumer Electronics Control (CEC)**

The Consumer Electronics Control (CEC) line is a high level command and control protocol, based on a single wire multidrop open drain communication bus running at approximately 1kHz (See Figure 3). While the HDMI link provides only a single point-to-point connection, up to ten (10) CEC devices may reside on the bus, and they may be daisy chained out through other physical connectors including other HDMI ports or other dedicated CEC links. The high level protocol of CEC can be implemented in a simple microcontroller or other interface with any I/OD (input/open-drain) GPIO.



**Figure 3. Typical  $\mu$ C I/OD Driver**

To limit possible EMI and ringing in this potentially complex connection topology, the rise- and fall-time of this line are limited by the specification. However, meeting the slew-rate limiting requirements with additional discrete circuitry in this bi-directional block is not trivial without an additional RX/TX control line to limit the output slew-rate without affecting the input sensing (See Figure 4).

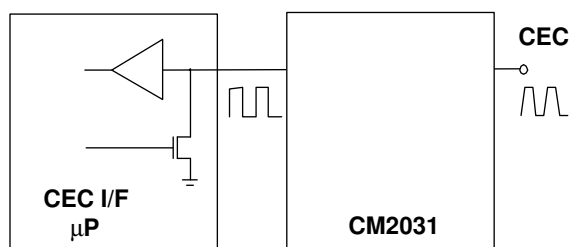


**Figure 4. Three-Pin External Buffer Control**

Simple CMOS buffers cannot be used in this application since the load can vary so much (total pullup of 27k $\Omega$  to less than 2k $\Omega$ , and up to 7.3nF total capacitance.) The CM2031 targets an output drive slew-rate of less than 100mV/ $\mu$ s regardless of static load for the CEC line. Additionally, the same internal circuitry will perform active

termination, thus reducing ringing and overshoot in entertainment systems connected to legacy or poorly designed CEC nodes.

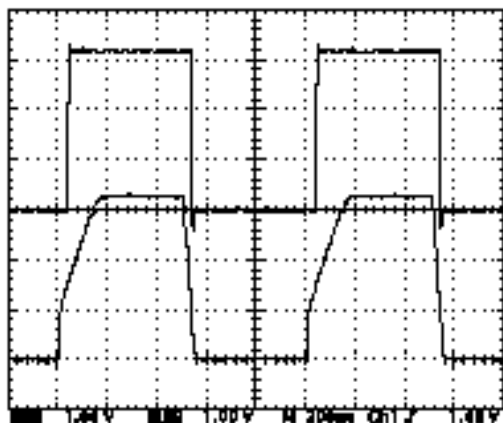
The CM2031's bi-directional slew rate limiting is integrated into the CEC level-shifter functionality thus allowing the designer to directly interface a simple low voltage CMOS GPIO directly to the CEC bus and simultaneously guarantee meeting all CEC output logic levels and HDMI slew-rate and isolation specifications (See Figure 5).



**Figure 5. Integrated CM2031 Solution**

The CM2031 also includes an internal backdrive protected static pullup 120μA current source from the CE\_SUPPLY rail in addition to the dynamic slew rate control circuitry.

Figure 6 shows a typical shaped CM2031 CEC output (bottom) against a ringing uncontrolled discrete solution (top).

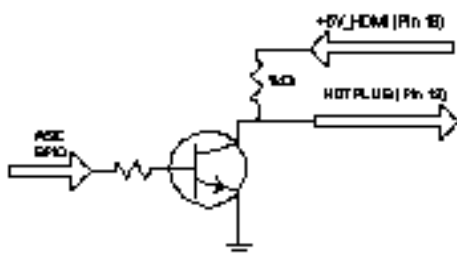


**Figure 6. CM2031 CEC Output**

## Hotplug Output Pullup Logic

The CM2031 includes flexible circuitry for active or passive control of the HDMI Sink's Hotplug Present Output line by integrating the 1k $\Omega$  pullup resistor.

Section 8.5 of the HDMI Specification allows the HDMI Sink to pulse the HotPlug line “low” for at least 100msec to indicate to the Source that the EEPROM should be re-read. This function can be implemented with a few discrete components as shown in Figure 7.



**Figure 7. Typical Discrete HPD Switching Circuit**

The Hot Plug Detect circuit of the CM2031 is specifically designed to provide this “pulse” capability and still pass CTS testing requirements.

When a logic “high” is applied to the HOTPLUG\_DET\_IN pin, an internal switch enables the 1k $\Omega$  pull-up. When a logic “low” is sensed on this pin, the 1k $\Omega$  logic resistor is disconnected, and a weak pulldown ensures a valid low output on the HDMI cable.

### 5V Passive Pullup

In the most basic implementation, where HOTPLUG is to be asserted only when the HDMI +5V supply is applied, simply tie HOTPLUG\_DET\_IN to the +5V supply and connect HOTPLUG\_DET\_OUT to HDMI Connector (Pin 19).

### Local Power Supply Pullup Passive

For a system that needs to inhibit the HOTPLUG signal when the local ASIC low voltage supply (“LV\_SUPPLY” on CM2031) has been powered, the designer can simply connect HOTPLUG\_DET\_OUT to the HDMI Connector (Pin 19) and tie HOTPLUG\_DET\_IN to the “LV\_SUPPLY” which can be 1.5V, 1.8V, 2.5V, etc. Then the internal 1k $\Omega$  pullup will be enabled between HOTPLUG\_DET\_OUT and 5V\_SUPPLY.

If a weak pullup is used on HOTPLUG\_DET\_IN, then this still allows dynamic switching by the local ASIC while still retaining the isolation/backdrive protection on this pin.

### Active Local Pullup Control

For a system where a low voltage GPIO signal needs to control the HOTPLUG pin (i.e. if the local system needs to boot up before asserting HOTPLUG) the ASIC GPIO can be connected directly to the HOTPLUG\_DET\_IN pin to control the 5V pullup “on” and “off.” A logic “low” on HOTPLUG\_DET\_IN will disable the 5V pullup, and a logic “high” will enable the pullup. (NOTE: If the ASIC Power-ON Reset {POR} default of the GPIO is high-impedance or defaults to an input, then the designer should include a weak pulldown on the GPIO to eliminate any POR glitches.)

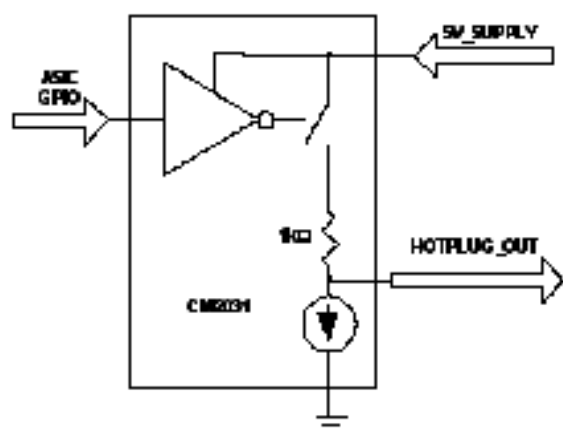


Figure 8. Simplified CM2031 HPD Circuit

## Ordering Information

| PART NUMBERING INFORMATION |          |                                   |              |
|----------------------------|----------|-----------------------------------|--------------|
| Pins                       | Package  | Lead-free Finish                  |              |
|                            |          | Ordering Part Number <sup>1</sup> | Part Marking |
| 38                         | TSSOP-38 | CM2031-A0TR                       | CM2031-A0TR  |

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

## Specifications

| ABSOLUTE MAXIMUM RATINGS        |                            |       |
|---------------------------------|----------------------------|-------|
| PARAMETER                       | RATING                     | UNITS |
| VCC5, VCCLV                     | 6.0                        | V     |
| DC Voltage at any Channel Input | [GND - 0.5] to [VCC + 0.5] | V     |
| Storage Temperature Range       | 65 to +150                 | °C    |

| STANDARD (RECOMMENDED) OPERATING CONDITIONS |                             |     |     |     |       |
|---------------------------------------------|-----------------------------|-----|-----|-----|-------|
| SYMBOL                                      | PARAMETER                   | MIN | TYP | MAX | UNITS |
| 5V_SUPPLY                                   | Operating Supply Voltage    |     | 5   | 5.5 | V     |
| LV_SUPPLY                                   | Bias Supply Voltage         | 1   | 3.3 | 5.5 | V     |
| CE_SUPPLY                                   | Bias Supply Voltage         | 3   | 3.3 | 3.6 | V     |
|                                             | Operating Temperature Range | 40  |     | 85  | °C    |

| ELECTRICAL OPERATING CHARACTERISTICS (SEE NOTE 1) |                                                   |                                                                                                  |      |      |      |       |
|---------------------------------------------------|---------------------------------------------------|--------------------------------------------------------------------------------------------------|------|------|------|-------|
| SYMBOL                                            | PARAMETER                                         | CONDITIONS                                                                                       | MIN  | TYP  | MAX  | UNITS |
| ICC5                                              | Operating Supply Current                          | 5V_SUPPLY = 5.0V,<br>CEC_OUT = 3.3V,<br>LV_SUPPLY = 3.3V,<br>CE_SUPPLY = 3.3V, DDC=5V;<br>Note 6 |      | 300  | 350  | μA    |
| ICCLV                                             | Bias Supply Current                               | LV_SUPPLY = 3.3V; Note 7                                                                         |      | 60   | 150  | μA    |
| ICCCE                                             | Bias Supply Current                               | CE_SUPPLY=3.3V, CEC_OUT=0V;<br>Notes 6 and 7                                                     |      | 60   | 150  | μA    |
| ICEC                                              | Current source on CEC pin                         | CE_SUPPLY=3.3V,                                                                                  | 111  | 120  | 128  | μA    |
| IOFF                                              | OFF state leakage current, level shifting NFET    | LV_SUPPLY=0V; Note 2<br>HOTPLUG_IN=0V                                                            |      | 0.1  | 5    | μA    |
| IBACKDRIVETMDS                                    | Current through TMDS pins when powered down       | All Supplies = 0V; TMDS_[2:0]+/-,<br>TMDS_CK+/- = 4V                                             |      | 0.1  | 5    | μA    |
| IBACKDRIVEDDC                                     | Current through DDC_DAT_OUT when powered down     | All Supplies = 0V;<br>DDC_DAT/CLK_OUT = 5V;<br>DDC_DAT/CLK_IN = 0V                               |      | 0.1  | 5    | μA    |
| IBACKDRIVEHOTPLUG                                 | Current through HOTPLUG_DET_OUT when powered down | All Supplies = 0V;<br>HOTPLUG_DET_OUT = 5V;<br>HOTPLUG_IN = 0V                                   |      | 0.1  | 5    | μA    |
| IBACKDRIVECEC                                     | Current through CE-REMOTE_OUT when powered down   | CE-REMOTE_IN = CE_SUPPLY < CE_REMOTE_OUT                                                         |      | 0.1  | 1.8  | μA    |
| CECSL                                             | CEC Slew Limit                                    | Measured from 10-90% or 90-10%                                                                   |      | 0.26 | 0.65 | V/μs  |
| CECRT                                             | CEC Rise Time                                     | Measured from 10-90%<br>Assumes a signal swing from 0-3.3V                                       | 26.4 |      | 250  | μs    |
| CECFT                                             | CEC Fall Time                                     | Measured from 90-10%<br>Assumes a signal swing from 0-3.3V                                       | 4    |      | 50   | μs    |
| RHOTPLUG                                          | Hotplug Resistance                                | Voltage on HotPlug_In is greater than the specified range below                                  | 0.8  | 1    | 1.2  | kΩ    |
| VTH                                               | Threshold Voltage to Assert 1kΩ                   |                                                                                                  | 1.5  |      | 5.5  | V     |
| VACC                                              | Turn On Threshold of I2C/DDC Accelerator          | Voltage is 0.3 X 5V_Supply; Note 2                                                               | 1.35 | 1.5  | 1.65 | V     |
| VON(DDC_OUT)                                      | Voltage drop across DDC level shifter             | LV_SUPPLY=3.3V, 3mA Sink at DDCIN, DDCOUT < VACC                                                 |      | 150  | 225  | mV    |

| SYMBOL             | PARAMETER                                                                                | CONDITIONS                                                                                         | MIN     | TYP  | MAX  | UNITS    |
|--------------------|------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------|---------|------|------|----------|
| VOL(DDC_IN)        | Logic Level (ASIC side) when I2C/DDC Logic Low Applied; (I2C pass-through compatibility) | DDC_OUT=0.4V, LV_SUPPLY=3.3V, 1.5k $\Omega$ pullup on DDC_OUT to 5.0V                              |         | 0.3  | 0.4  | V        |
| tr(DDC)            | DDC_OUT Line Risettime, VACC < VDDC_OUT < (5V_Supply-0.5V)                               | DDC_IN floating, LV_SUPPLY=3.3V, 1.5k $\Omega$ pullup on DDC_OUT to 5.0V, Bus Capacitance = 1500pF |         |      | 1    | $\mu$ S  |
| VF                 | Diode Forward Voltage                                                                    | IF = 8mA, TA = 25°C; Note 2                                                                        |         |      |      |          |
|                    | Top Diode                                                                                |                                                                                                    | 0.6     | 0.85 | 0.95 | V        |
|                    | Bottom Diode                                                                             |                                                                                                    | 0.6     | 0.85 | 0.95 | V        |
| VESD               | ESD Withstand Voltage (IEC)                                                              | Pins 4, 7, 10, 13, 20, 21, 22, 23, 24, 27, 30, 33, TA = 25°C; Note 2                               | $\pm 8$ |      |      | kV       |
| VESD               | ESD Withstand Voltage (HBM)                                                              | Pins 1, 2, 16, 17, 18, 19, 37, and 38, TA = 25°C; Note 3                                           | $\pm 2$ |      |      | kV       |
| VCL                | Channel Clamp Voltage                                                                    | TA=25°C, IPP=1A, tP=8/20 $\mu$ S; Note 5                                                           |         | 11.0 |      | V        |
|                    | Positive Transients                                                                      |                                                                                                    |         | 2.0  |      | V        |
|                    | Negative Transients                                                                      |                                                                                                    |         |      |      |          |
| RDYN               | Dynamic Resistance                                                                       | TA=25°C, IPP=1A, tP=8/20 $\mu$ S<br>Any I/O pin to Ground; Note 5                                  |         | 1.4  |      | $\Omega$ |
|                    | Positive Transients                                                                      |                                                                                                    |         | 0.9  |      | $\Omega$ |
|                    | Negative Transients                                                                      |                                                                                                    |         |      |      |          |
| ILEAK              | TMDS Channel Leakage Current                                                             | TA = 25°C                                                                                          |         | 0.01 | 1    | $\mu$ A  |
| CIN, TMDS          | TMDS Channel Input Capacitance                                                           | 5V_SUPPLY=5.0V, Measured at 1MHz, VBIAS=2.5V                                                       |         | 0.9  | 1.2  | pF       |
| $\Delta$ CIN, TMDS | TMDS Channel Input Capacitance Matching                                                  | 5V_SUPPLY=5.0V, Measured at 1MHz, VBIAS=2.5V; Note 4                                               |         | 0.05 |      | pF       |
| CMUTUAL            | Mutual Capacitance between signal pin and adjacent signalpin                             | 5V_SUPPLY=0V, Measured at 1MHz, VBIAS=2.5V                                                         |         | 0.07 |      | pF       |
| CIN, DDCOUT        | Level Shifting Input Capacitance, Capacitance to GND                                     | 5V_SUPPLY=0V, Measured at 100KHz, VBIAS=2.5V                                                       |         | 10   |      | pF       |

| SYMBOL      | PARAMETER                                            | CONDITIONS                                                 | MIN | TYP | MAX | UNITS |
|-------------|------------------------------------------------------|------------------------------------------------------------|-----|-----|-----|-------|
| CIN, CECOUT | Level Shifting Input Capacitance, Capacitance to GND | 5V_SUPPLY=0V,<br>Measured at 100KHz, VBIAS=1.65V           |     | 10  |     | pF    |
| CIN, HPOUT  | Level Shifting Input Capacitance, Capacitance to GND | 5V_SUPPLY=0V,<br>Measured at 100KHz,<br>VBIAS=2.5V; Note 2 |     | 10  |     | pF    |

Note 1: Operating Characteristics are over Standard Operating Conditions unless otherwise specified.

Note 2: Standard IEC61000-4-2,  $C_{DISCHARGE}=150\text{pF}$ ,  $R_{DISCHARGE}=330\Omega$ , 5V\_SUPPLY=5V, 3.3V\_SUPPLY=3.3V, LV\_SUPPLY=3.3V, GND=0V.

Note 3: Human Body Model per MIL-STD-883, Method 3015,  $C_{DISCHARGE}=100\text{pF}$ ,  $R_{DISCHARGE}=1.5\text{k}\Omega$ , 5V\_SUPPLY=5V, 3.3V\_SUPPLY=3.3V, LV\_SUPPLY=3.3V, GND=0V.

Note 4: Intra-pair matching, each TMDS pair (i.e. D+, D-).

Note 5: These measurements performed with no external capacitor on  $V_p$  ( $V_p$  floating).

Note 6: These static measurements do not include AC activity on controlled I/O lines.

Note 7: This measurement does not include supply current for the 120 $\mu\text{A}$  current source on the CEC pin.

## Performance Information

Typical Filter Performance ( $T_A=25^\circ\text{C}$ , DC Bias=0V, 50 Ohm Environment)

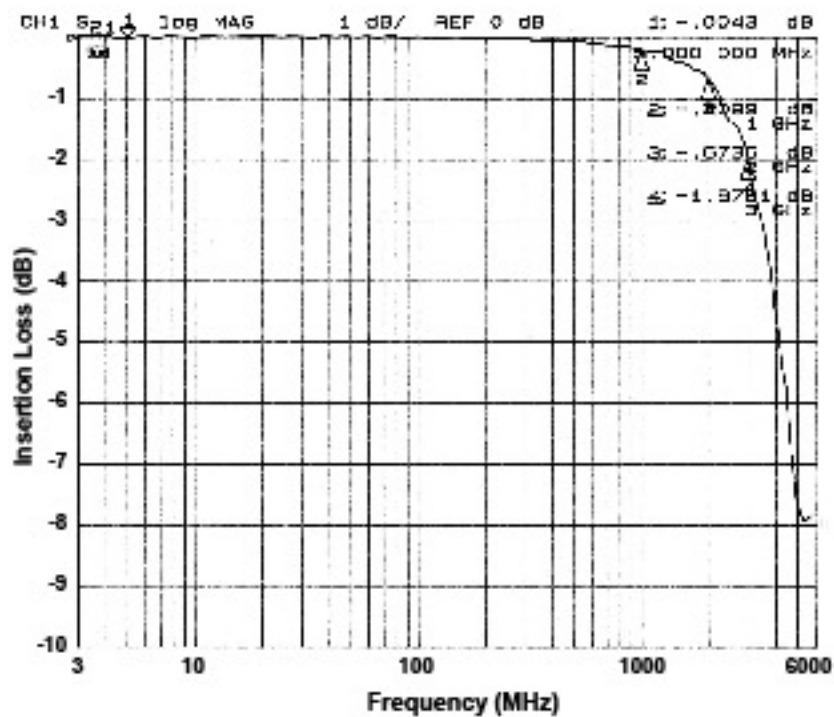


Figure 9. Insertion Loss vs. Frequency (TMDS\_D1- to GND)

## Application Information

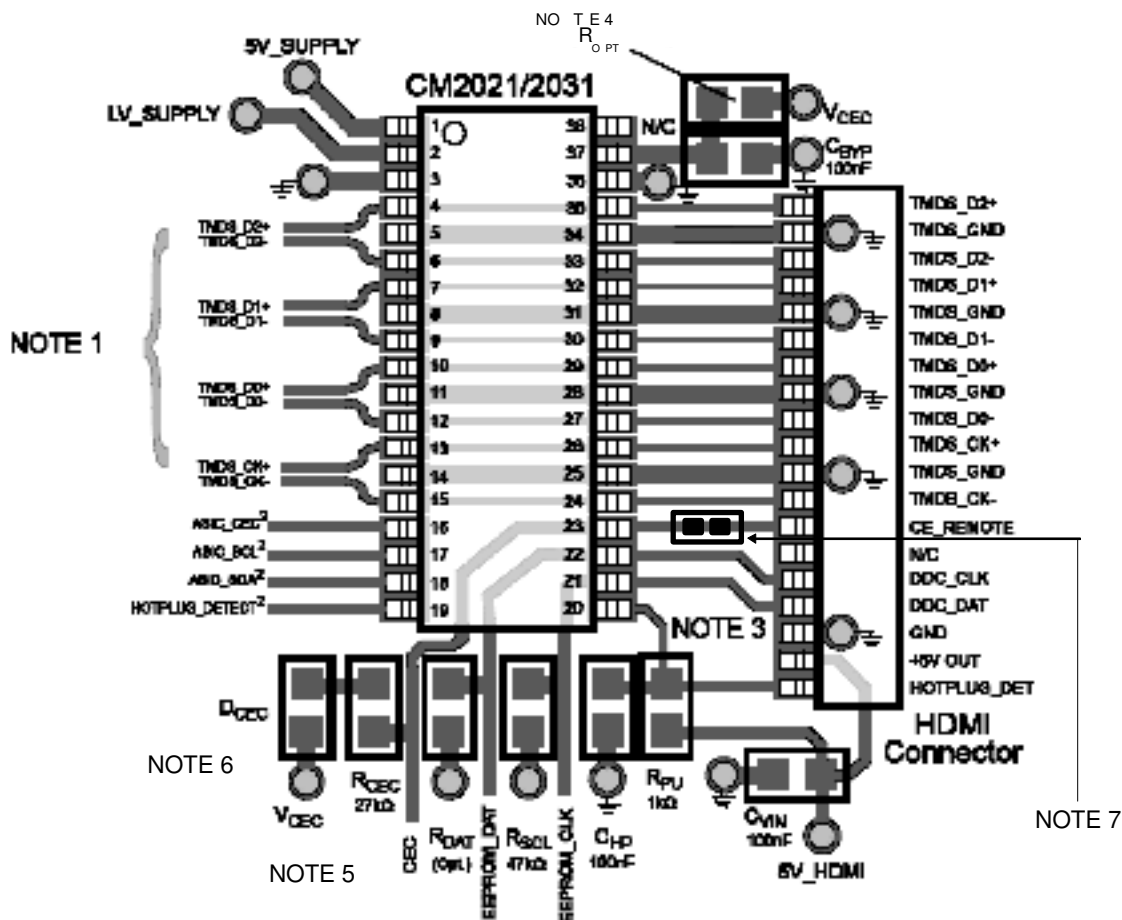


Figure 10. Typical Application for CM2031

## LAYOUT NOTES

- 1 **Differential TMDS Pairs should be designed as normal 100Ω HDMI Microstrip. *Single Ended (decoupled) TMDS traces underneath MediaGuard™, and traces between MediaGuard™ and Connector should be tuned to match chip/connector IBIS parasitics. (See [MediaGuard™ Layout Application Notes.](#))***
- 2 Level Shifter signals should be biased with a weak pullup to the desired local LV\_SUPPLY. If the local ASIC includes sufficient pullups to register a logic high, then external pullups may not be needed.
- 3 Place MediaGuard™ as close to the connector as possible, and as with any controlled impedance line always avoid placing any silkscreen printing over TMDS traces.
- 4 CM2021/CM2031 footprint compatibility - For the CM2031, Pin 37 becomes the V<sub>CEC</sub> power supply pin for the slew-rate limiting circuitry. This can be supplied by a 0Ω jumper to V<sub>CEC</sub> which should be depopulated to utilize the CM2021. The 100nF C<sub>BYP</sub> is recommended for all applications.
- 5 CEC pullup isolation - The 27k R<sub>CEC</sub> and a Schottky D<sub>CEC</sub> provide the necessary isolation for the CEC pullup.

Note: *This circuitry is used only in the CM2021.* Depopulate the components for CM2031 applications in a CM2021/ CM2031 dual footprint layout.

<sup>6</sup> Footprint compatibility - The CM2031 has (built-in) internal backdrive protection.

The CM2021 does not have internal backdrive protection and requires the external  $R_{CEC}$  and  $D_{CEC}$  components.

<sup>7</sup> (For CM2031) If CEC firmware *is not* implemented, *do not* populate with  $0\Omega$  resistor. If CEC firmware is implemented, then populate with  $0\Omega$  resistor.

(For CM2021) Populate with  $0\Omega$  resistor in either case.

## Application Information (cont'd)

### Design Considerations

#### DUT On vs. DUT Off

Many HDMI CTS tests require a power off condition on the System Under Test. Many discrete ESD diode configurations can be forward biased when their VDD rail is lower than the I/O pin bias, thereby exhibiting extremely high apparent capacitance measurements, for example. The *MediaGuard*<sup>TM</sup> backdrive isolation circuitry limits this current to less than  $5\mu A$ , and will help ensure HDMI compliance.

**Please review all of the current HDMI design guidelines available at:**

<http://www.calmicro.com/applications/customer/downloads/current-cmd-mediaguard-design-guidelines.zip>

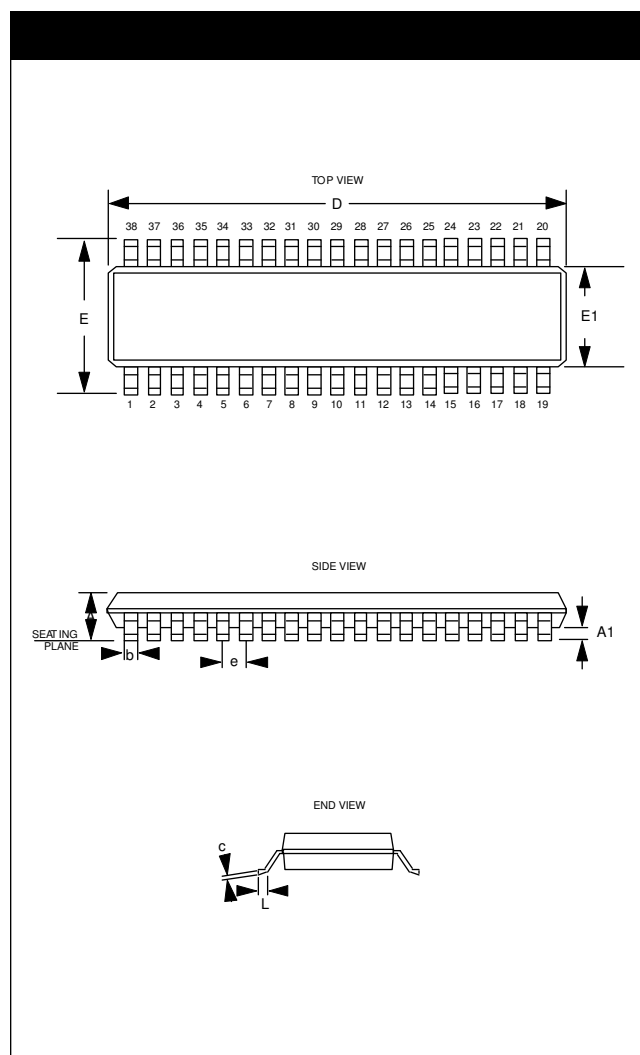
## Mechanical Details

### TSSOP-38 Mechanical Specifications

CM2031 devices are supplied in 38-pin TSSOP packages. Dimensions are presented below.

For complete information on the TSSOP-38, see the California Micro Devices TSSOP Package Information document.

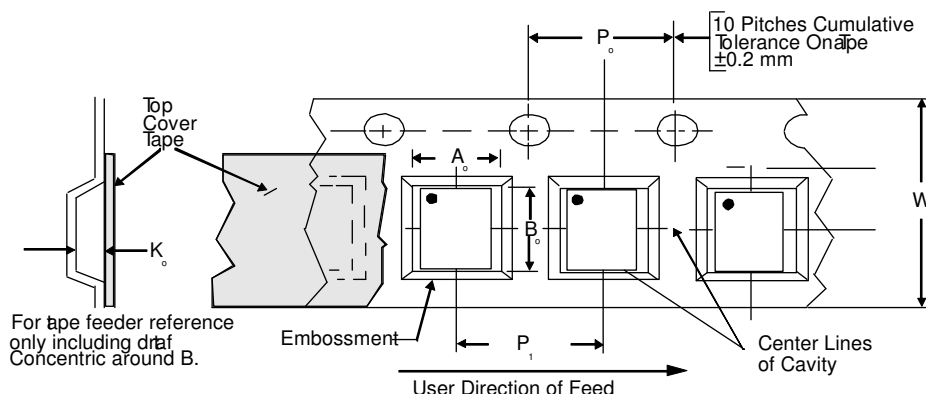
| PACKAGE DIMENSIONS                 |                         |      |           |       |
|------------------------------------|-------------------------|------|-----------|-------|
| Package                            | TSSOP                   |      |           |       |
| JEDEC No.                          | MO-153 (Variation BD-1) |      |           |       |
| Pins                               | 38                      |      |           |       |
| Dimensions                         | Millimeters             |      | Inches    |       |
|                                    | Min                     | Max  | Min       | Max   |
| A                                  | —                       | 1.20 | —         | 0.047 |
| A1                                 | 0.05                    | 0.15 | 0.002     | 0.006 |
| b                                  | 0.17                    | 0.27 | 0.007     | 0.011 |
| c                                  | 0.09                    | 0.20 | 0.004     | 0.008 |
| D                                  | 9.60                    | 9.80 | 0.378     | 0.386 |
| E                                  | 6.40 BSC                |      | 0.252 BSC |       |
| E1                                 | 4.30                    | 4.50 | 0.169     | 0.177 |
| e                                  | 0.50 BSC                |      | 0.020 BSC |       |
| L                                  | 0.45                    | 0.75 | 0.018     | 0.030 |
| # per tape and reel                | 2500 pieces             |      |           |       |
| Controlling dimension: millimeters |                         |      |           |       |



Package Dimensions for TSSOP-38

**Tape and Reel Specifications**

| PART NUMBER | PACKAGE SIZE<br>(mm) | POCKET SIZE (mm)<br>$B_0 \times A_0 \times K_0$ | TAPE WIDTH<br>W | REEL<br>DIAMETER | QTY PER<br>REEL | $P_0$ | $P_1$ |
|-------------|----------------------|-------------------------------------------------|-----------------|------------------|-----------------|-------|-------|
| CM2031      | 9.70 X 6.40 X 1.20   | 10.20 X 6.90 X 1.80                             | 16mm            | 330mm (13")      | 2500            | 4mm   | 12mm  |



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