ON Semiconductor®

# HDMI Transmitter Port Protection and Interface Device

# CM2020-01TR

## Features

- HDMI 1.3 compliant
- 0.05pF matching capacitance between the TMDS intra-pair
- Overcurrent output protection
- Level shifting/isolation circuitry
- ±8kV ESD protection on all external lines
- Matched 0.5mm trace spacing (TSSOP)
- Simplified layout for HDMI connectors
- Backdrive protection
- RoHS-compliant, lead-free packaging

## Applications

- PC
- Consumer electronics
- Set top box
- DVD/RW players

## Product Description

The CM2020-01TR HDMI Transmitter Port Protection and Interface Device is specifically designed for next generation HDMI Source interface protection.

An integrated package provides all ESD, level shift, overcurrent output protection and backdrive protection for an HDMI port in a single 38-Pin TSSOP package.

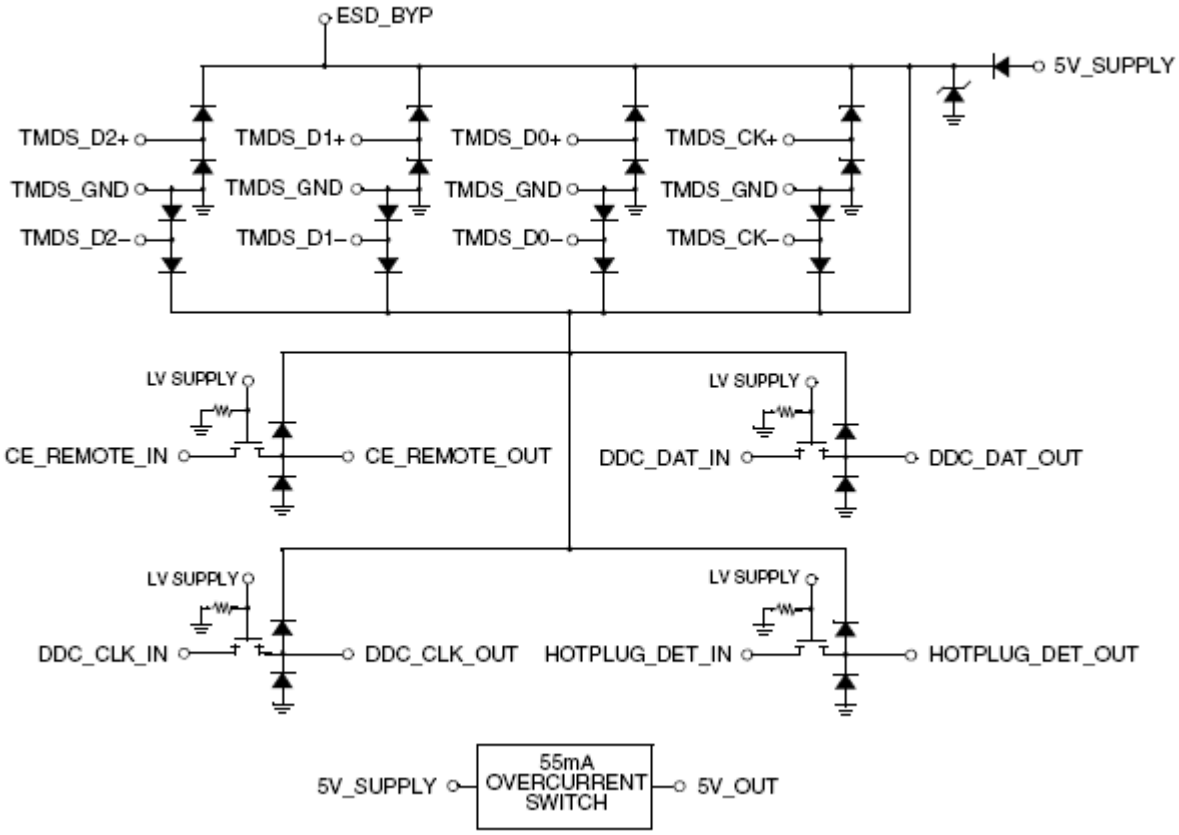
The CM2020-01TR part is specifically designed to complement the CM2021 protection part in HDMI receivers (displays, DTV, CE devices, etc.).

The CM2020-01TR also incorporates a silicon overcurrent protection device for +5V supply voltage output to the connector.


May 2010 – Rev. 4

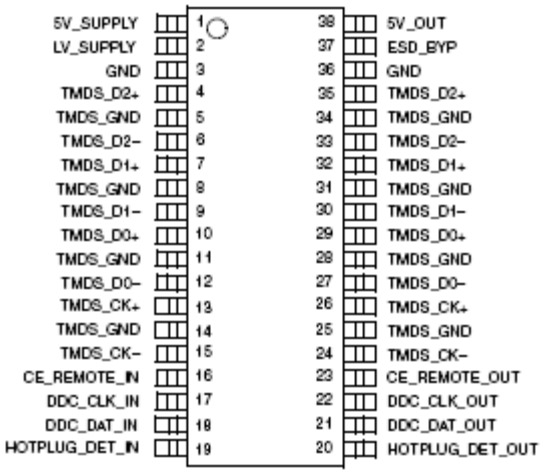
Publication Order Number:
CM2020-01TR/D

## Electrical Schematic




## PACKAGE / PINOUT DIAGRAM

TOP VIEW




38-PIN TSSOP PACKAGE

Note: This drawing is not to scale.

## PIN DESCRIPTIONS

| PINS | NAME | ESD Level | DESCRIPTION |
|---|---|---|---|
| 4, 35 | TMDS_D2+ | 8kV[2] | TMDS 0.9pF ESD protection.[1] |
| 6, 33 | TMDS_D2– | 8kV[2] | TMDS 0.9pF ESD protection.[1] |
| 7, 32 | TMDS_D1+ | 8kV[2] | TMDS 0.9pF ESD protection.[1] |
| 9, 30 | TMDS_D1– | 8kV[2] | TMDS 0.9pF ESD protection.[1] |
| 10, 29 | TMDS_D0+ | 8kV[2] | TMDS 0.9pF ESD protection.[1] |
| 12, 27 | TMDS_D0– | 8kV[2] | TMDS 0.9pF ESD protection.[1] |
| 13, 26 | TMDS_CK+ | 8kV[2] | TMDS 0.9pF ESD protection.[1] |
| 15, 24 | TMDS_CK– | 8kV[2] | TMDS 0.9pF ESD protection.[1] |
| 16 | CE_REMOTE_IN | 2kV[3] | LV_SUPPLY referenced logic level into ASIC. |
| 23 | CE_REMOTE_OUT | 8kV[2] | 5V_SUPPLY referenced logic level out plus 3.5pF ESD to connector. |
| 17 | DDC_CLK_IN | 2kV[3] | LV_SUPPLY referenced logic level into ASIC. |
| 22 | DDC_CLK_OUT | 8kV[2] | 5V_SUPPLY referenced logic level out plus 3.5pF ESD to connector. |
| 18 | DDC_DAT_IN | 2kV[3] | LV_SUPPLY referenced logic level into ASIC. |
| 21 | DDC_DAT_OUT | 8kV[2] | 5V_SUPPLY referenced logic level out plus 3.5pF ESD to connector. |
| 19 | HOTPLUG_DET_IN | 2kV[3] | LV_SUPPLY referenced logic level into ASIC. |
| 20 | HOTPLUG_DET_OUT | 8kV[2] | 5V_SUPPLY referenced logic level out plus 3.5pF ESD to connector. |
| 2 | LV_SUPPLY | 2kV[3] | Bias for CE / DDC / HOTPLUG level shifters. |
| 1 | 5V_SUPPLY | 2kV[3] | Current source for 5V_OUT. |
| 38 | 5V_OUT | 8kV[2] | 55mA minimum overcurrent protected 5V output. This output must be bypassed with a 0.1 F ceramic capacitor. |
| 37 | ESD_BYP | 2kV[3] | This pin may be connected to a 0.1 F ceramic capacitor, but it is not necessary. |
| 3, 36 | GND | N/A | Supply GND reference. |
| 5, 34, 8, 31, 11, 28, 14, 25 | TMDS_GND | N/A | TMDS ESD and Parasitic GND return.[4] |

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

Note 2: Standard IEC 61000-4-2, $C_{DISCHARGE}$=150pF, $R_{DISCHARGE}$=330Ω, 5V_SUPPLY and LV_SUPPLY within recommended operating conditions, GND=0V, 5V_OUT (pin 38), each bypassed with a 0.1µF ceramic capacitor connected to GND.

Note 3: Human Body Model per MIL-STD-883, Method 3015, $C_{DISCHARGE}$=100pF, $R_{DISCHARGE}$=1.5kΩ, 5V_SUPPLY and LV_SUPPLY within recommended operating conditions, GND=0V and 5V_OUT (pin 38), and each bypassed with a 0.1µF ceramic capacitor connected to GND.

Note 4: 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

Below, two scenarios are discussed to illustrate what can happen when a powered device is connected to an unpowered device via an HDMI interface, substantiating the need for backdrive protection on this type of interface.

In the first example a DVD player is connected to a TV via an HDMI interface. If the DVD player is switched off and the TV is left on, there is a possibility of reverse current flow back into the main power supply rail of the DVD player. Typically, the DVD's power supply has some form of bulk supply capacitance associated with it. Because all CMOS logic exhibits a very high impedance on the power rail node when "off," if there may be very little parasitic shunt resistance, and even with as little as a few milliamps of "backdrive" current flowing into the power rail, it is possible over time to charge that bulk supply capacitance 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, these devices may not reset properly when the DVD player is turned back on.

In a more serious scenario, if any SOC devices are incorporated in the design which have built-in level shifter and DRC diodes for ESD protection, there is even a risk for permanent damage. In this case, if there is a pullup resistor (such as with DDC) on the other end of the cable, that resistance will pull the SOC chips "output" up to a high level. This will forward bias the upper ESD diode in the DRC and charge the bulk capacitance in a similar fashion as described in the first example. If this 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 CM2020-01TR was designed to block backdrive current, guaranteeing no more than 5mA on any I/O pin when the I/O pin voltage is greater than the CM2020-01TR supply voltage.

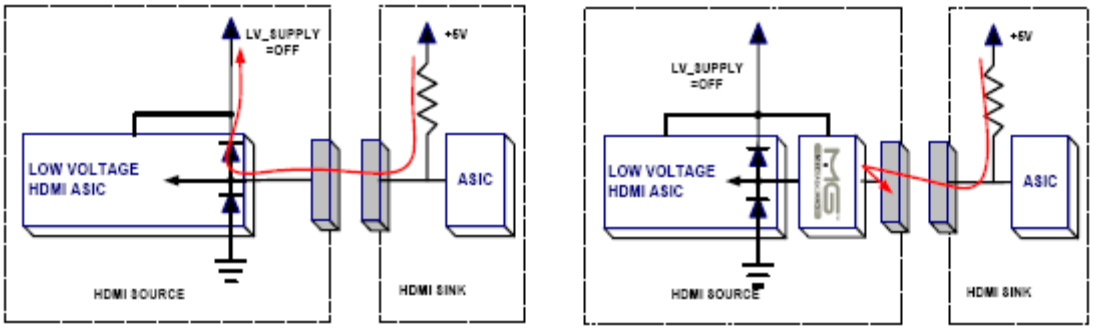



**Figure 1. Backdrive Protection Diagram**

## Ordering Information

| PART NUMBERING INFORMATION | | | |
|---|---|---|---|
| | | Lead-free Finish | |
| Pins | Package | Ordering Part Number[1] | Part Marking |
| 38 | TSSOP-38 | CM2020-01TR | CM2020-01TR |

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

## Specifications

| ABSOLUTE MAXIMUM RATINGS | | |
|---|---|---|
| PARAMETER | RATING | UNITS |
| $V_{CC5V}$, $V_{CCLV}$ | 6.0 | V |
| DC Voltage at any Channel Input | 6.0 | V |
| Storage Temperature Range | –65 to +150 | ℃ |

| STANDARD (RECOMMENDED) OPERATING CONDITIONS | | | | | |
|---|---|---|---|---|---|
| SYMBOL | PARAMETER | MIN | TYP | MAX | UNITS |
| 5V_SUPPLY | Operating Supply Voltage | GND | 5 | 5.5 | V |
| LV_SUPPLY | Bias Supply Voltage | 1 | 3.3 | 5.5 | V |
| | Operating Temperature Range | –40 | | 85 | ℃ |

## ELECTRICAL OPERATING CHARACTERISTICS [1]

| SYMBOL | PARAMETER | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| $I_{CC5V}$ | Operating Supply Current | 5V_SUPPLY = 5.0V | | 110 | 130 | μA |
| $I_{CCLV}$ | Bias Supply Current | LV_SUPPLY = 3.3V | | 1 | 5 | μA |
| $V_{DROP}$ | 5V_OUT Overcurrent Output Drop | 5V_SUPPLY= 5.0V, $I_{OUT}$=55mA | | 65 | 100 | mV |
| $I_{SC}$ | 5V_OUT Short Circuit Current Limit | 5V_SUPPLY= 5.0V, 5V_OUT = GND | 90 | 135 | 175 | mA |
| $I_{OFF}$ | OFF state leakage current, level shifting NFET | LV_SUPPLY=0V | | 0.1 | 5 | μA |
| $I_{BACKDRIVE}$ | Current conducted from output pins to V_SUPPLY rails when powered down | 5V_SUPPLY < $V_{CH\_OUT}$; Signal pins: TMDS_D[2:0]+/–, TMDS_CK+/–, CE_REMOTE_OUT, DDC_DAT_OUT, DDC_CLK_OUT, HOTPLUG_DET_OUT, 5V_OUT Only | | 0.1 | 5 | μA |
| $I_{BACKDRIVE,}$ CEC | Current through CE-REMOTE_OUT when powered down | CE-REMOTE_IN = CE_SUPPLY < CE_REMOTE_OUT | | 0.1 | 1 | μA |
| $V_{ON}$ | VOLTAGE drop across level shifting NFET when ON | LV_SUPPLY = 2.5V, $V_S$ = GND, $I_{DS}$ = 3mA | 75 | 95 | 140 | mV |
| $V_F$ | Diode Forward Voltage<br>Top Diode<br>Bottom Diode | $I_F$ = 8mA, $T_A$ = 25°C | <br>0.6<br>0.6 | <br>0.85<br>0.85 | <br>0.95<br>0.95 | <br>V<br>V |
| $V_{ESD}$ | ESD Withstand Voltage: Contact discharge per IEC 61000-4-2 Standard | Pins 4, 7, 10, 13, 20, 21, 22, 23, 24, 27, 30, 33, 38; Note 2 | ±8 | | | kV |
| $V_{CL}$ | Channel Clamp Voltage<br>Positive Transients<br>Negative Transients | $T_A$ = 25°C, $I_{PP}$ = 1A, $t_P$ = 8/20μs; Note 3 | | <br>11.0<br>–2.0 | | <br>V<br>V |
| $R_{DYN}$ | Dynamic Resistance<br>Positive Transients<br>Negative Transients | $T_A$ = 25°C, $I_{PP}$ = 1A, $t_P$ = 8/20μs; Notes 3 | | <br>1.2<br>0.9 | | <br>Ω<br>Ω |
| $I_{LEAK}$ | TMDS Channel Leakage Current | $T_A$ = 25°C | | 0.01 | 1 | μA |
| $C_{IN,}$ TMDS | TMDS Channel Input Capacitance | 5V_SUPPLY= 5.0V, Measured at 1MHz, $V_{BIAS}$=2.5V | | 0.9 | 1.2 | pF |

| SYMBOL | PARAMETER | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| $\Delta C_{IN,}$ TMDS | TMDS Channel Input Capacitance Matching | 5V_SUPPLY= 5.0V, Measured at 1MHz, $V_{BIAS}$=2.5V; Note 4 | | 0.05 | | pF |
| $C_{IN,}$ DDC | Level Shifting Input Capacitance, Capacitance to GND | 5V_SUPPLY= 5V, Measured at 100KHz, $V_{BIAS}$=2.5V | | 3.5 | 4 | pF |
| $C_{IN,}$ CEC | Level Shifting Input Capacitance, Capacitance to GND | 5V_SUPPLY= 5V, Measured at 100KHz, $V_{BIAS}$=2.5V | | 3.5 | 4 | pF |
| $C_{IN,}$ HP | Level Shifting Input Capacitance, Capacitance to GND | 5V_SUPPLY= 5V, Measured at 100KHz, $V_{BIAS}$=2.5V | | 3.5 | 4 | pF |

Note 1: Operating Characteristics are over Standard Operating Conditions unless otherwise specified.
Note 2: Standard IEC 61000-4-2, $C_{DISCHARGE}$=150pF, $R_{DISCHARGE}$=330Ω, 5V_SUPPLY and LV_SUPPLY within recommended operating conditions, GND=0V, 5V_OUT (pin 38), each bypassed with a 0.1µF ceramic capacitor connected to GND.
Note 3: These measurements performed with no external capacitor on ESD_BYP.
Note 4: Intra-pair matching, each TMDS pair (i.e. D+, D–).

## Performance Information

**Typical Filter Performance ($T_A$=25°C, DC Bias=0V, 50 Ohm Environment)**

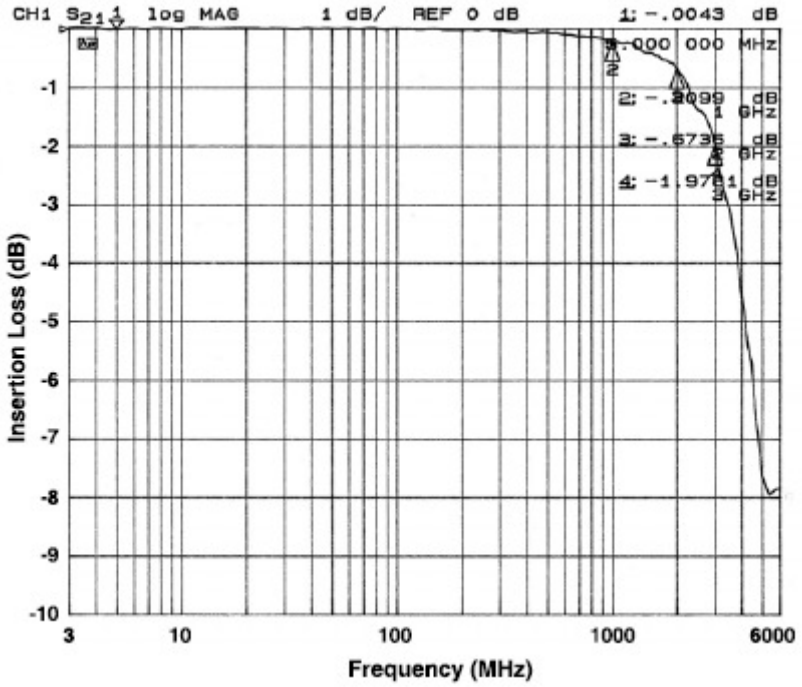
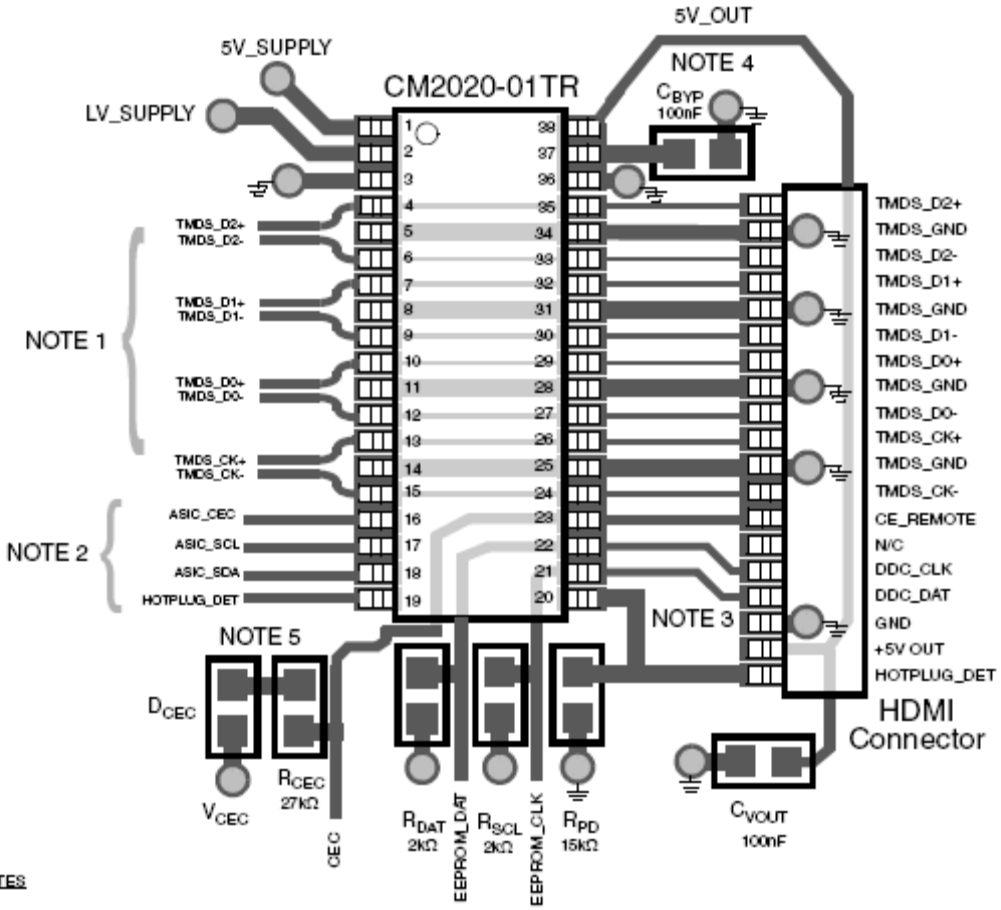



**Figure 2. Insertion Loss vs. Frequency (TMDS_D1- to GND)**

## Application Information




LAYOUT NOTES

NOTE 1) Differential TMDS Pairs should be designed as normal 100Ω HDMI microstrip. Single Ended TMDS traces underneath CM2020 and between CM2020 and Connector should be tuned to match chip/connector parasitics. (See MediaGuard™ Application Notes.)

NOTE 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 when the CM2020 NFET is "off", then external pullups are not needed.

NOTE 3) Place CM2020 as close to conector as possible, and as with any controlled impedance line avoid ANY silkscreening over TMDS lines.

NOTE 4) CBYP (Bypass Capacitor) is optional for the CM2020-01TR.

NOTE 5) CEC pullup isolation. The 27k $R_{CEC}$ and a Schottky $D_{CEC}$ provide the necessary isolation for the CEC pullup.

**Figure 3. Typical Application for CM2020-01TR**

## Application Information (cont'd)

### Design Considerations

#### 5V Overcurrent Output

Maximum Overcurrent Protection output drop at 55mA on 5V_OUT is 100mV. To meet HDMI output requirements of 4.8-5.3V, an input of greater than 4.9V should be used (i.e. 5.1V ±4%). A 0.1□F ceramic bypass capacitor on this output is also recommended.

#### Hotplug Detect Input

To meet the requirements of HDMI CTS TID7-12, the following pullup/pulldown configuration is recommended for a 3.3V ±10% internal VCC rail (See Figure 4 below). A 0.1µF ceramic capacitor is recommended for additional edge debounce and ESD bypass.

#### DUT On vs. DUT Off

Many HDMI CTS tests require a power off condition on the System Under Test. Many Dual Rail Clamp (DRC) ESD diode configurations will 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™* backdrive isolation circuitry limits this current to <5µA, and will help ensure compliance.

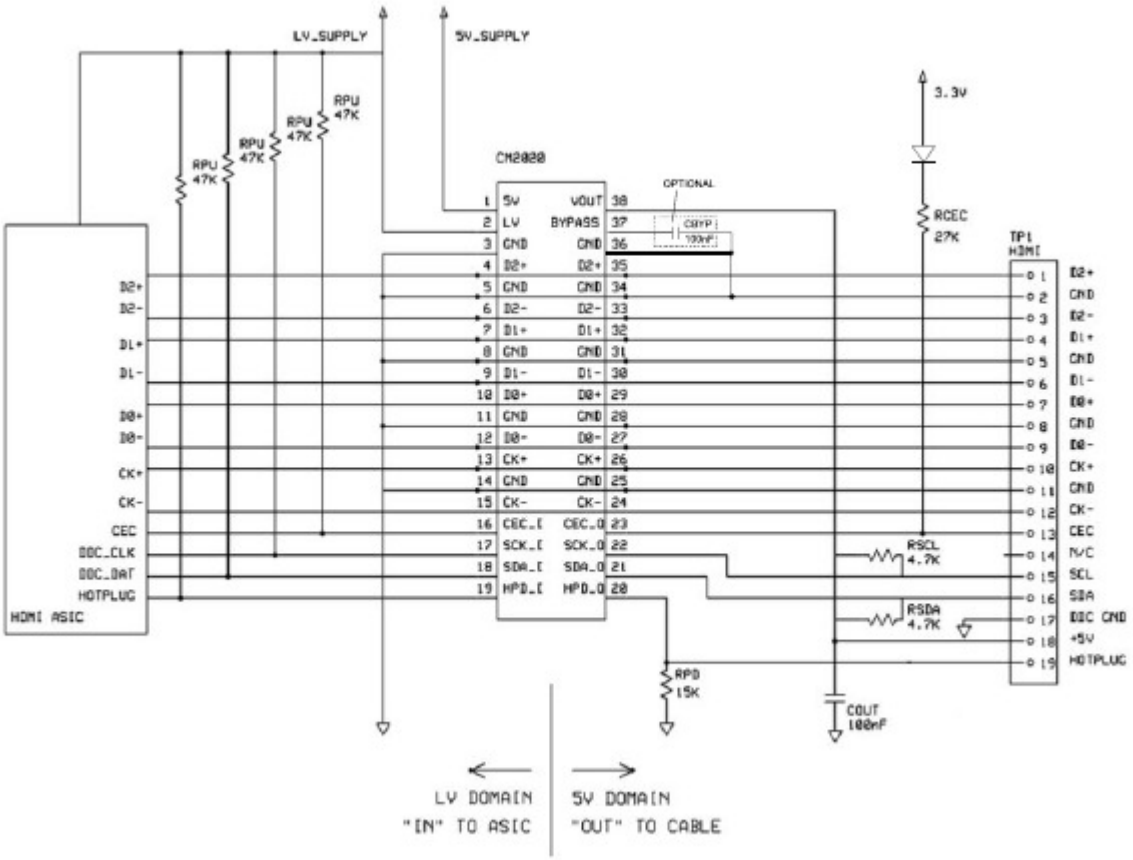


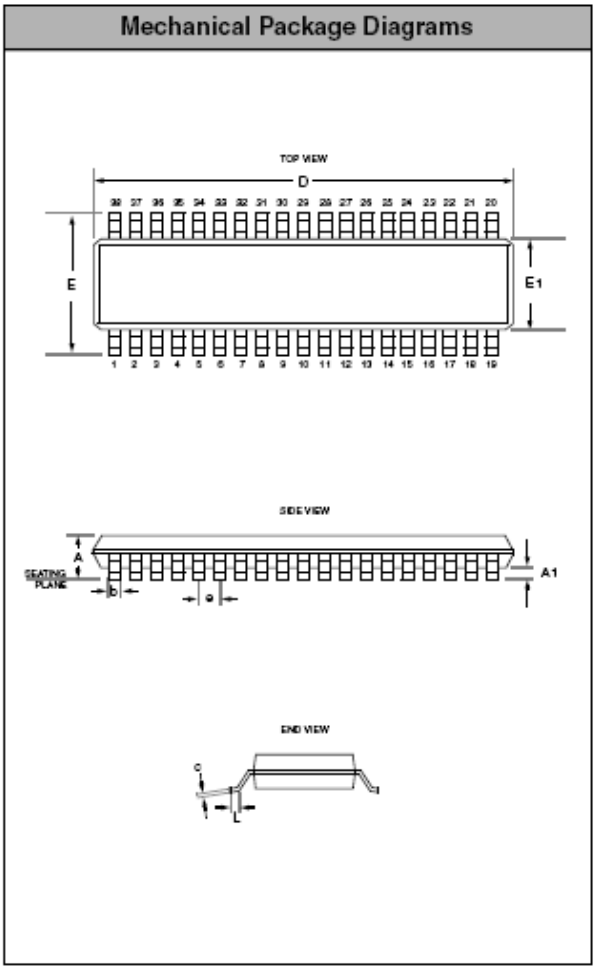

**Figure 4. Design Example**

## Mechanical Details

### TSSOP-38 Mechanical Specifications

CM2020-01TR 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.

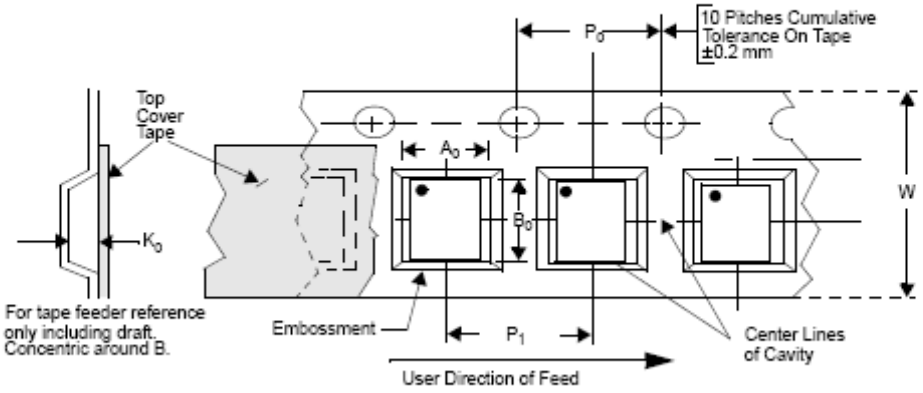
| PACKAGE DIMENSIONS | | | | |
|---|---|---|---|---|
| **Package** | TSSOP | | | |
| **JEDEC No.** | MO-153 (Variation BD-1) | | | |
| **Pins** | 38 | | | |
| **Dimensions** | **Millimeters** | | **Inches** | |
| | **Min** | **Max** | **Min** | **Max** |
| **A** | — | 1.20 | — | 0.047 |
| **A1** | 0.05 | 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 (mm) | POCKET SIZE (mm) $B_0$ X $A_0$ X $K_0$ | TAPE WIDTH W | REEL DIAMETER | QTY PER REEL | $P_0$ | $P_1$ |
|---|---|---|---|---|---|---|---|
| CM2020-01TR | 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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