

# IP4778CZ38

HDMI ESD protection, DDC buffering and hot plug control

Rev. 3 — 31 March 2011

Product data sheet

## HDMI

### 1. General description

The IP4778CZ38 is designed for HDMI receiver host interface protection. The IP4778CZ38 includes DDC buffering, slew rate acceleration and decoupling, hot plug control, backdrive protection, CEC slew rate control, optional multiplexing of DDC signals, and high-level ESD protection diodes for all HDMI signals.

The DDC lines are buffered using a new buffering concept which decouples the internal capacitive load from the external capacitive load. This allows higher PCB design flexibility for the DDC lines with respect to a maximum load of 50 pF. This buffering also boosts the DDC signals, allowing the use of longer HDMI cables having a higher capacitive load than 700 pF. The CEC slew rate limiter prevents ringing on the CEC line and greatly reduces the number of discrete components needed by the CEC application. HDMI receiver and system GPIO applications are simplified by an internal hot plug driver module and hot plug control.

The DDC, hot plug and CEC lines are backdrive protected to guarantee HDMI interface signals are not pulled down if the system is powered down or enters Standby mode.

All TMDS intra-pairs are protected by a special diode configuration offering a low line capacitance of 0.7 pF only (to ground) and 0.05 pF between the TMDS pairs. These diodes provide protection to components downstream from ESD voltages of up to  $\pm 8$  kV contact in accordance with the IEC 61000-4-2, level 4 standard.

### 2. Features and benefits

- Pb-free and RoHS compliant
- Robust ESD protection without degradation after several ESD strikes
- Low leakage even after several hundred ESD discharges
- Very high diode switching speed (ns) and low line capacitance of 0.7 pF to ground and 0.05 pF between channels ensures signal integrity
- DDC capacitive decoupling between system side and HDMI connector side and drive cable buffering with capacitive load ( $> 700$  pF)
- Hot plug control for direct connection to system GPIO
- CEC ringing prevention by slew rate limiter
- DDC and hot plug enable signal for multiplexing and backdrive protection
- All TMDS lines with integrated rail-to-rail clamping diodes with downstream ESD protection of  $\pm 8$  kV in accordance with IEC 61000-4-2, level 4
- Matched 0.5 mm trace spacing
- Component count reduction of HDMI receiver application



- Highest integration in a small footprint, PCB level, optimized RF routing, 38-pin TSSOP lead-free package
- Choice of system compatible or RF routing optimized pinning variants

### 3. Applications

- The IP4778CZ38 can be used for a wide range of HDMI sink devices e.g.:
  - ◆ TV
  - ◆ Projectors
  - ◆ PC monitors
  - ◆ HDMI buffer modules (extensions of HDMI cable length)
  - ◆ HDMI picture performance quality enhancer modules

### 4. Ordering information

**Table 1. Ordering information**

Type number	Package		
	Name	Description	Version
IP4778CZ38	TSSOP38	plastic thin shrink small outline package; 38 leads; body width 4.4 mm; lead pitch 0.5 mm	SOT510-1
IP4778CZ38/V			

5. Functional diagram

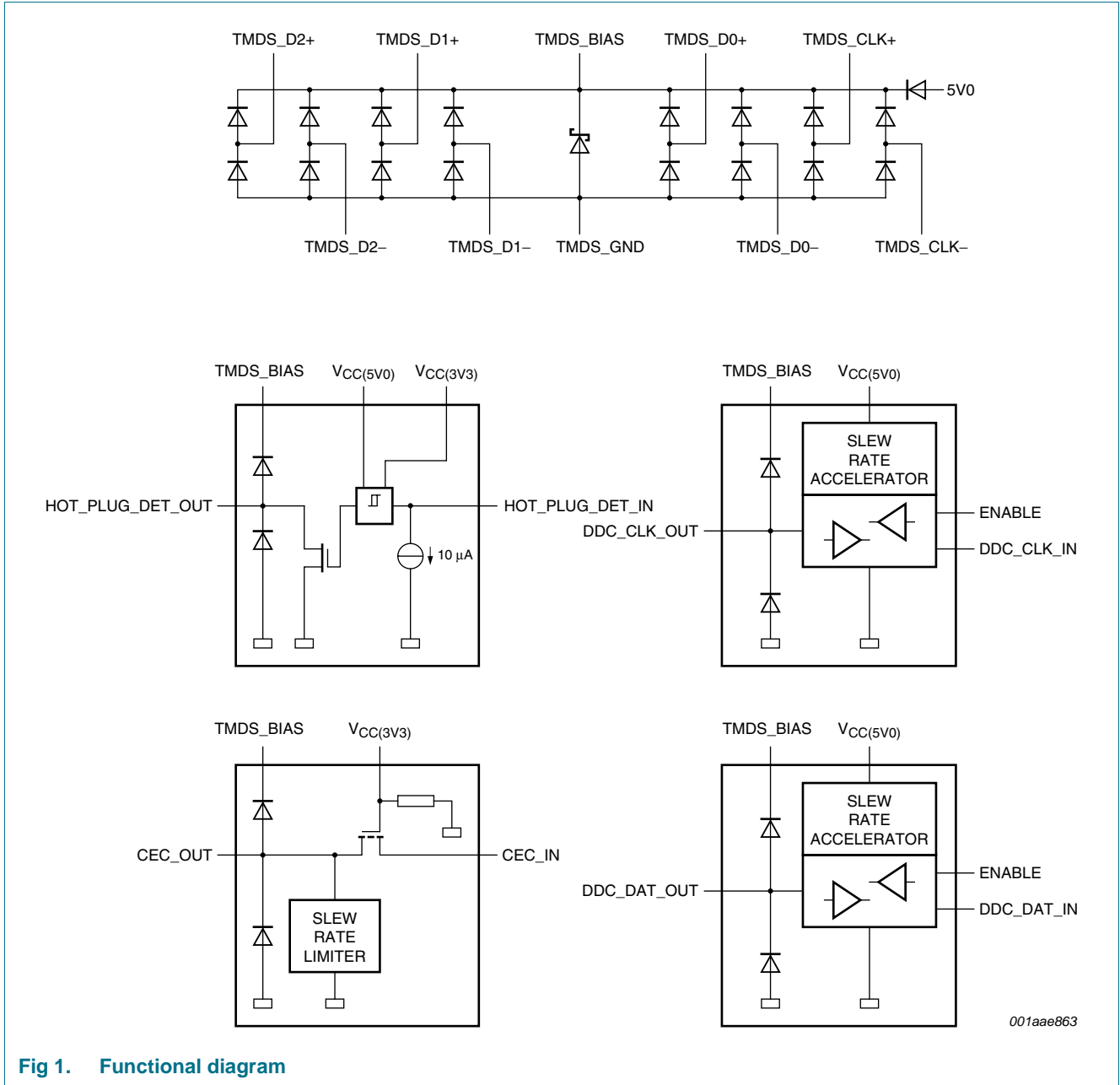
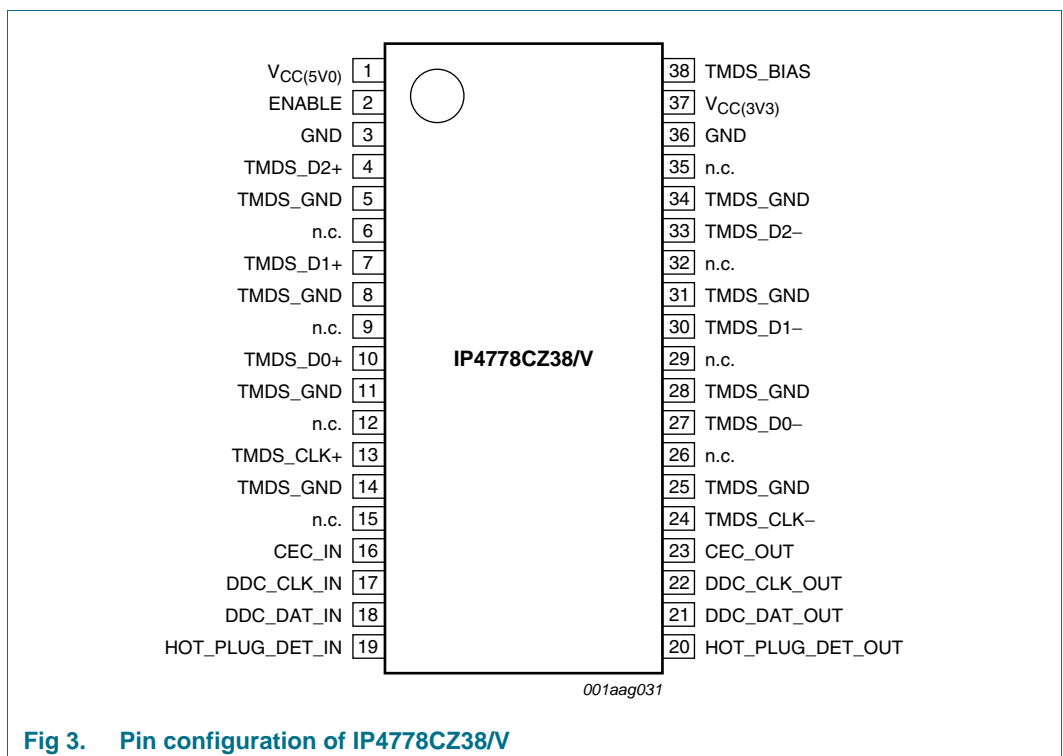
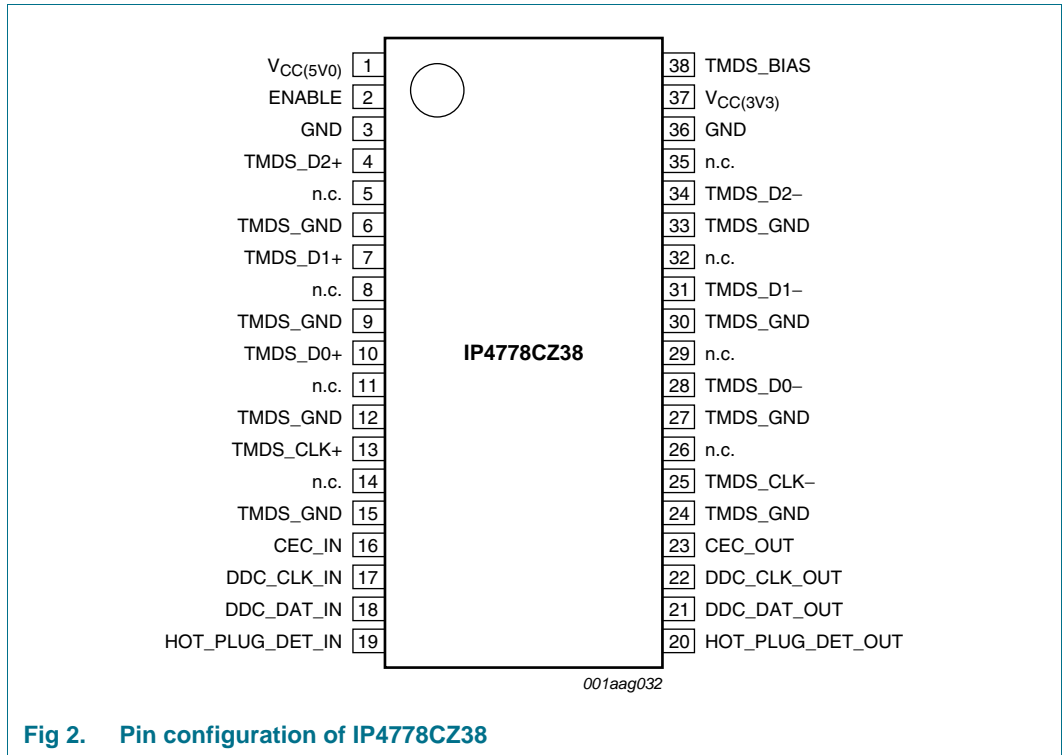


Fig 1. Functional diagram

## 6. Pinning information

### 6.1 Pinning



## 6.2 Pin description

Table 2. Pin description

Symbol	Pin		Description
	IP4778CZ38	IP4778CZ38/V	
V <sub>CC(5V0)</sub>	1	1	supply voltage for DDC and hot plug circuits
ENABLE	2	2	enable for DDC and hot plug circuits
GND	3	3	ground for DDC, hot plug and CEC circuits <sup>[1]</sup>
TMDS_D2+	4	4	ESD protection TMDS channel D2+ <sup>[2]</sup>
TMDS_GND	6	5	ground for TMDS channel <sup>[1]</sup>
n.c.	5	6	not connected <sup>[2]</sup>
TMDS_D1+	7	7	ESD protection TMDS channel D1+ <sup>[2]</sup>
TMDS_GND	9	8	ground for TMDS channel <sup>[1]</sup>
n.c.	8	9	not connected <sup>[2]</sup>
TMDS_D0+	10	10	ESD protection TMDS channel D0+ <sup>[2]</sup>
TMDS_GND	12	11	ground for TMDS channel <sup>[1]</sup>
n.c.	11	12	not connected <sup>[2]</sup>
TMDS_CLK+	13	13	ESD protection TMDS channel CLK+ <sup>[2]</sup>
TMDS_GND	15	14	ground for TMDS channel <sup>[1]</sup>
n.c.	14	15	not connected <sup>[2]</sup>
CEC_IN	16	16	CEC signal input to system controller <sup>[3]</sup>
DDC_CLK_IN	17	17	DDC clock input to system controller <sup>[3]</sup>
DDC_DAT_IN	18	18	DDC data input to system controller <sup>[3]</sup>
HOT_PLUG_DET_IN	19	19	hot plug Detect input from system GPIO <sup>[3]</sup>
HOT_PLUG_DET_OUT	20	20	hot plug Detect output to HDMI connector <sup>[4]</sup>
DDC_DAT_OUT	21	21	DDC data output to HDMI connector <sup>[4]</sup>
DDC_CLK_OUT	22	22	DDC clock output to HDMI connector <sup>[4]</sup>
CEC_OUT	23	23	CEC signal output to HDMI connector <sup>[3]</sup>
TMDS_CLK-	25	24	ESD protection TMDS channel CLK- <sup>[2]</sup>
TMDS_GND	24	25	ground for TMDS channel <sup>[1]</sup>
n.c.	26	26	not connected <sup>[2]</sup>
TMDS_D0-	28	27	ESD protection TMDS channel D0- <sup>[2]</sup>
TMDS_GND	27	28	ground for TMDS channel <sup>[1]</sup>
n.c.	29	29	not connected <sup>[2]</sup>
TMDS_D1-	31	30	ESD protection TMDS channel D1- <sup>[2]</sup>
TMDS_GND	30	31	ground for TMDS channel <sup>[1]</sup>

**Table 2. Pin description ...continued**

Symbol	Pin		Description
	IP4778CZ38	IP4778CZ38/V	
n.c.	32	32	not connected <sup>[2]</sup>
TMDS_D2-	34	33	ESD protection TMDS channel D2- <sup>[2]</sup>
TMDS_GND	33	34	ground for TMDS channel <sup>[1]</sup>
n.c.	35	35	not connected <sup>[2]</sup>
GND	36	36	ground for DDC, hot plug and CEC circuits <sup>[1]</sup>
V <sub>CC(3V3)</sub>	37	37	supply voltage for CEC circuit
TMDS_BIAS	38	38	bias input for TMDS ESD protection. This pin must be connected to a 0.1 µF capacitor.

- [1] Pins GND and TMDS\_GND are internally connected.
- [2] This pin must always be connected to the IC pin located opposite via a PCB track to guarantee correct functionality; see [Figure 15](#).
- [3] V<sub>CC(3V3)</sub> referenced logic level in.
- [4] V<sub>CC(5V0)</sub> referenced logic level out.

## 7. Limiting values

**Table 3. Limiting values**

In accordance with the Absolute Maximum Rating System (IEC 60134).

Symbol	Parameter	Conditions	Min	Max	Unit
V <sub>CC</sub>	supply voltage		GND – 0.5	5.5	V
V <sub>I</sub>	input voltage	at input pins	GND – 0.5	5.5	V
V <sub>ESD</sub>	electrostatic discharge voltage	connector side pins (to ground); IEC 61000-4-2, level 4	<sup>[1]</sup>		
		contact	–8	+8	kV
		board side pins; IEC 61000-4-2, level 1	<sup>[2]</sup>		
		contact	–2	+2	kV
P <sub>tot</sub>	total power dissipation	DDC operating at 100 kHz	-	8	mW
T <sub>stg</sub>	storage temperature		–55	+125	°C

- [1] Connector side pins:  
 TMDS\_D2+, TMDS\_D2-, TMDS\_D1+, TMDS\_D1-, TMDS\_D0+, TMDS\_D0-,  
 TMDS\_CLK+, TMDS\_CLK-,  
 CEC\_OUT,  
 DDC\_DAT\_OUT and DDC\_CLK\_OUT,  
 HOT\_PLUG\_DET\_OUT.
- [2] Board side pins:  
 CEC\_IN,  
 DDC\_DAT\_IN and DDC\_CLK\_IN,  
 HOT\_PLUG\_DET\_IN,  
 ENABLE.

## 8. Static characteristics

**Table 4. TMDS protection circuit**  
*T<sub>amb</sub> = 25 °C; unless otherwise specified.*

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
<b>Zener diode</b>						
V <sub>BRzd</sub>	Zener diode breakdown voltage	I = 1 mA	6	-	9	V
R <sub>dyn</sub>	dynamic resistance	I = 1 A; IEC 61000-4-5/9				
		positive transient	-	2.4	-	Ω
		negative transient	-	1.3	-	Ω
<b>Protection diode</b>						
I <sub>bck</sub>	back current	from pins TMDS_x to pin TMDS_BIAS; V <sub>CC(5V0)</sub> = 0 V; V <sub>CC(3V3)</sub> = 0 V	-	0.1	5	μA
I <sub>L(r)</sub>	reverse leakage current	V <sub>I</sub> = 3.0 V	-	1	-	μA
V <sub>F</sub>	forward voltage		-	0.7	-	V
V <sub>CL(ch)trt(pos)</sub>	positive transient channel clamping voltage	V <sub>ESD</sub> = 8 kV per IEC 61000-4-2; voltage 30 ns after trigger	[1]	8	-	V
<b>TMDS channel: pins TMDS_x</b>						
C <sub>ch(TMDS)</sub>	TMDS channel capacitance	V <sub>CC(5V0)</sub> = 5 V; f = 1 MHz; V <sub>bias</sub> = 2.5 V	[2]	0.7	-	pF
ΔC <sub>ch(TMDS)</sub>	TMDS channel capacitance difference	V <sub>CC(5V0)</sub> = 5 V; f = 1 MHz; V <sub>bias</sub> = 2.5 V	[2]	0.05	-	pF
C <sub>ch(mutual)</sub>	mutual channel capacitance	between signal pin TMDS_x and pin n.c.; V <sub>CC(5V0)</sub> = 0 V; f = 1 MHz; V <sub>bias</sub> = 2.5 V	[2]	0.07	-	pF

[1] This measurement is performed with a 0.1 μF external capacitor on pin TMDS\_BIAS.

[2] This parameter is guaranteed by design.

**Table 5. DDC circuit**  
*V<sub>CC(3V3)</sub> = 2.7 V to 5.5 V; V<sub>CC(5V0)</sub> = 4.5 V to 5.5 V; GND = 0 V; T<sub>amb</sub> = 25 °C; unless otherwise specified.*

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
<b>Supplies: pins V<sub>CC(5V0)</sub> and V<sub>CC(3V3)</sub></b>						
V <sub>CC(5V0)</sub>	supply voltage (5.0 V)		4.5	5.0	5.5	V
V <sub>CC(3V3)</sub>	supply voltage (3.3 V)		2.7	3.3	5.5	V
I <sub>CC(5V0)</sub>	supply current (5.0 V)	V <sub>CC(5V0)</sub> = 5.5 V; both channels HIGH: DDC_DAT_OUT = V <sub>CC(5V0)</sub> ; DDC_CLK_OUT = V <sub>CC(5V0)</sub>	-	0.5	1.0	mA
		V <sub>CC(5V0)</sub> = 5.5 V; both channels LOW: DDC_DAT_IN = GND; DDC_CLK_IN = GND; DDC_DAT_OUT = open; DDC_CLK_OUT = open	-	0.5	1.0	mA
I <sub>CC(3V3)</sub>	supply current (3.3 V)	no pull-up resistor connected to V <sub>CC(3V3)</sub>	-	-	0.1	μA

**Table 5. DDC circuit ...continued**

$V_{CC(3V3)} = 2.7\text{ V to }5.5\text{ V}$ ;  $V_{CC(5V0)} = 4.5\text{ V to }5.5\text{ V}$ ;  $GND = 0\text{ V}$ ;  $T_{amb} = 25\text{ }^\circ\text{C}$ ; unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
<b>Board side: pins DDC_CLK_OUT and DDC_DAT_OUT</b>						
Used as input						
$V_{IH}$	HIGH-level input voltage		$0.7 \times V_{CC(3V3)}$	-	5.5	V
$V_{IL}$	LOW-level input voltage		-0.5	-	$0.3 \times V_{CC(3V3)}$	V
$I_{IL}$	LOW-level input current	$V_I = 0.2\text{ V}$	-	-	1	$\mu\text{A}$
$V_{IK}$	input clamping voltage	$I_I = -18\text{ mA}$	-	-	-1.2	V
$I_{LI}$	input leakage current	$V_I = 3.6\text{ V}$	-	-	$\pm 1$	$\mu\text{A}$
$C_i$	input capacitance	$V_I = 3\text{ V or }0\text{ V}$				
		$V_{CC(3V3)} = 3.3\text{ V}$	-	8	10	pF
		$V_{CC(3V3)} = 3.0\text{ V}$	-	8	10	pF
Used as output						
$V_{OL}$	LOW-level output voltage	$I_{OL} = 100\text{ }\mu\text{A or }6\text{ mA}$	-	200	-	mV
$I_{OH}$	HIGH-level output current	$V_O = 3.6\text{ V}$	-	-	1	$\mu\text{A}$
$C_o$	output capacitance	$V_I = 3\text{ V or }0\text{ V}$				
		$V_{CC(3V3)} = 3.3\text{ V}$	-	8	10	pF
		$V_{CC(3V3)} = 3.0\text{ V}$	-	8	10	pF
<b>Connector side: pins DDC_CLK_IN and DDC_DAT_IN</b>						
Used as input						
$V_{IH}$	HIGH-level input voltage		-	410	-	mV
$V_{IL}$	LOW-level input voltage		-	400	-	mV
$I_{IL}$	LOW-level input current	DDC_DAT_OUT, DDC_CLK_OUT, $V_I = 0.2\text{ V}$	-	-	10	$\mu\text{A}$
$V_{IK}$	input clamping voltage	$I_I = -18\text{ mA}$	-	-	-1.2	V
$I_{LI}$	input leakage current	$V_I = 3.6\text{ V}$	-	-	$\pm 1$	$\mu\text{A}$
$C_i$	input capacitance	$V_I = 3\text{ V or }0\text{ V}$				
		$V_{CC(3V3)} = 3.3\text{ V}$	-	7	9	pF
		$V_{CC(3V3)} = 3.0\text{ V}$	-	7	9	pF
Used as output						
$V_{OL}$	LOW-level output voltage	$I_{OL} = 100\text{ }\mu\text{A or }3\text{ mA}$	-	700	-	mV
$I_{OH}$	HIGH-level output current	$V_O = 3.6\text{ V}$	-	-	1	$\mu\text{A}$
$C_o$	output capacitance	$V_I = 3\text{ V or }0\text{ V}$				
		$V_{CC(3V3)} = 3.3\text{ V}$	-	8	10	pF
		$V_{CC(3V3)} = 3.0\text{ V}$	-	8	10	pF



**Table 6. CEC circuit**

$V_{CC(3V3)} = 2.7\text{ V to }5.5\text{ V}$ ;  $GND = 0\text{ V}$ ;  $T_{amb} = 25\text{ }^\circ\text{C}$ ; unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
<b>Board side: input pin CEC_IN</b>						
$C_{I(ch-GND)(levsh)}$	level shifting input capacitance from channel to ground	$V_{CC(3V3)} = 0\text{ V}$ ; $f = 1\text{ MHz}$ ; $V_{bias} = 2.5\text{ V}$	[1] -	12	16	pF
$SR_r$	rising slew rate	$V_I > 1.8\text{ V}$	-	10	-	mV/ $\mu\text{s}$
<b>N-FET</b>						
$\Delta V_{on}$	on-state voltage drop	N-FET state = on; $V_{CC(3V3)} = 2.5\text{ V}$ ; $V_S = GND$ ; $I_{DS} = 3\text{ mA}$	[2] -	125	140	mV
<b>Connector side: output pin CEC_OUT</b>						
$I_{LI}$	input leakage current		-1	+0.1	+1	$\mu\text{A}$
$R_{dyn}$	dynamic resistance	$I = 1\text{ A}$ ; IEC 61000-4-5/9				
		positive transient	-	2.4	-	$\Omega$
		negative transient	-	1.3	-	$\Omega$
$V_{CL(ch)trt(pos)}$	positive transient channel clamping voltage	$V_{ESD} = 8\text{ kV}$ per IEC 61000-4-2; voltage 30 ns after trigger; $T_{amb} = 25\text{ }^\circ\text{C}$	[3] -	8	-	V

[1] This parameter is guaranteed by design.

[2] For level shifting N-FET.

[3] This measurement is performed with a 0.1  $\mu\text{F}$  external capacitor on pin TMDS\_BIAS.

**Table 7. Enable circuit**

$V_{CC(3V3)} = 2.7\text{ V to }5.5\text{ V}$ ;  $GND = 0\text{ V}$ ;  $T_{amb} = 25\text{ }^\circ\text{C}$ ; unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
<b>Board side: input pin ENABLE[1]</b>						
$V_{IH}$	HIGH-level input voltage	HIGH = enable	$0.7 \times V_{CC(3V3)}$	-	$V_{CC(5V0)} + 0.5$	V
$V_{IL}$	LOW-level input voltage	LOW = disable	-0.5	-	$0.3 \times V_{CC(3V3)}$	V
$I_{IL}$	LOW-level input current	$V_I = 0.2\text{ V}$ ; $V_{CC(3V3)} = 5.5\text{ V}$	-	10	-	$\mu\text{A}$
$I_{LI}$	input leakage current		-1	+0.1	+1	$\mu\text{A}$
$C_i$	input capacitance	$V_I = 3\text{ V or }0\text{ V}$	-	3	7	pF

[1] The ENABLE pin has to be connected permanently to  $V_{CC(3V3)}$  if no enable control is needed.

**Table 8. hot plug control circuit**

$V_{CC(5V0)} = 4.5\text{ V to }5.5\text{ V}$ ;  $V_{CC(3V3)} = 2.7\text{ V to }5.5\text{ V}$ ;  $GND = 0\text{ V}$ ;  $T_{amb} = 25\text{ }^\circ\text{C}$ ; unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
<b>Board side: input pin HOT_PLUG_DET_IN</b>						
$V_{IH}$	HIGH-level input voltage	HIGH = hot plug off	$0.7 \times V_{CC(3V3)}$	-	$V_{CC(5V0)} + 0.5$	V
$V_{IL}$	LOW-level input voltage	LOW = hot plug on	-0.5	-	$0.3 \times V_{CC(3V3)}$	V
$I_{IL}$	LOW-level input current	$V_I = 2.0\text{ V}$ ; $V_{CC(3V3)} = 5.5\text{ V}$	-	10	-	$\mu\text{A}$
$I_{LI}$	input leakage current		-1	+0.1	+1	$\mu\text{A}$
$C_i$	input capacitance	$V_I = 3\text{ V or }0\text{ V}$	-	4	7	pF
<b>Connector side: output pin HOT_PLUG_DET_OUT</b>						
$I_{LI}$	input leakage current		-1	+0.1	+1	$\mu\text{A}$
$C_i$	input capacitance	$V_I = 3\text{ V or }0\text{ V}$	-	6	7	pF
$V_{on}$	on-state voltage	$I_I = 5\text{ mA}$	-	400	-	mV

## 9. Dynamic characteristics

**Table 9. DDC circuits**

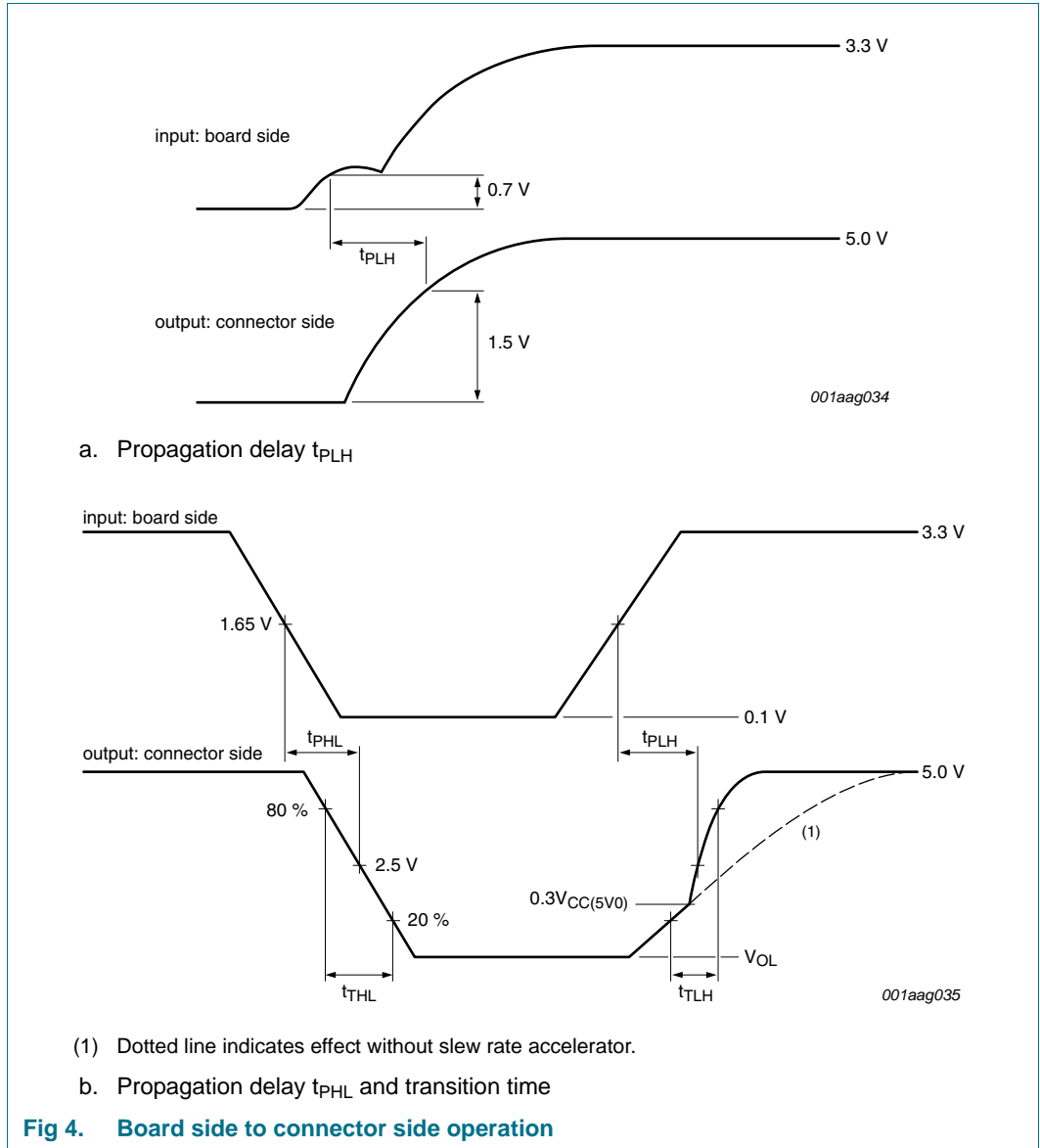
$V_{CC(3V3)} = 2.7\text{ V to }5.5\text{ V}$ ;  $V_{CC(5V0)} = 4.5\text{ V to }5.5\text{ V}$ ;  $GND = 0\text{ V}$ ;  $T_{amb} = 25\text{ }^\circ\text{C}$ ; unless otherwise specified.

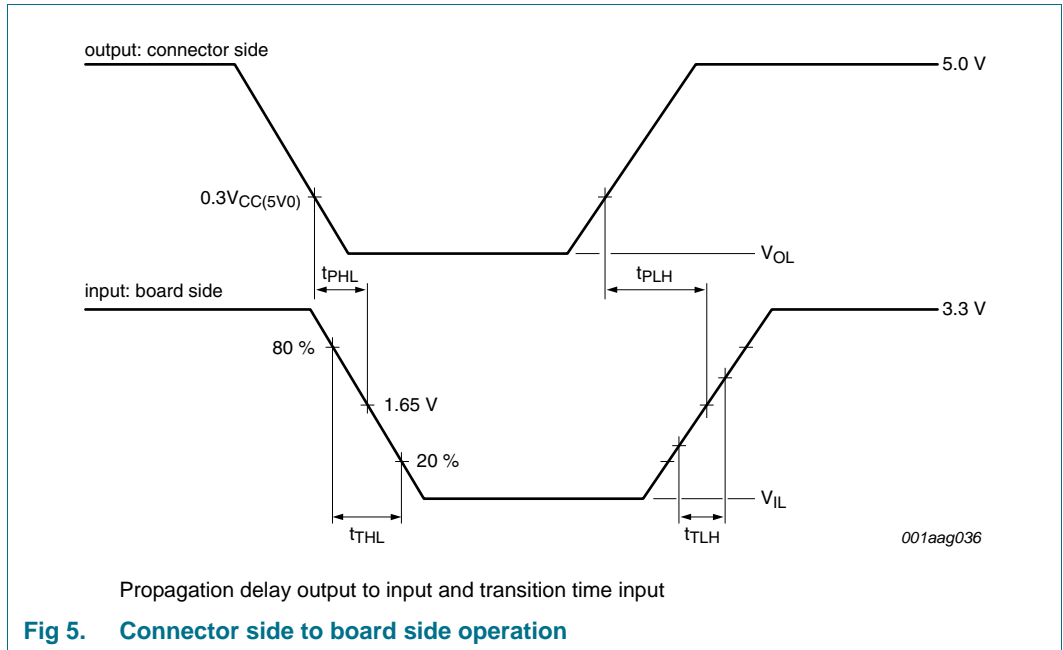
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
<b>Board side to connector side; see Figure 4</b>						
Pins DDC_CLK_IN to DDC_CLK_OUT and DDC_DAT_IN to DDC_DAT_OUT						
$t_{PLH}$	LOW to HIGH propagation delay		[1]	150	270	300 ns
$t_{PHL}$	HIGH to LOW propagation delay		[1]	125	210	225 ns
Pins DDC_CLK_OUT and DDC_DAT_OUT						
$t_{TLH}$	LOW to HIGH transition time	$R_L = 1.35\text{ k}\Omega$ ; $C_L = 50\text{ pF}$		90	110	130 ns
$t_{THL}$	HIGH to LOW transition time		[1]	2	3	5 ns
<b>Connector side to board side; see Figure 5</b>						
Pins DDC_CLK_OUT to DDC_CLK_IN and DDC_DAT_OUT to DDC_DAT_IN						
$t_{PLH}$	LOW to HIGH propagation delay			90	110	130 ns
$t_{PHL}$	HIGH to LOW propagation delay		[1]	20	30	40 ns
Pins DDC_CLK_IN and DDC_DAT_IN						
$t_{TLH}$	LOW to HIGH transition time			100	120	140 ns
$t_{THL}$	HIGH to LOW transition time		[1]	2	3	5 ns
<b>Enable: pin ENABLE</b>						
$t_{su}$	set-up time	pin ENABLE = HIGH before start condition	[2]	100	-	- ns
$t_h$	hold time	pin ENABLE = HIGH after stop condition	[2]	100	-	- ns

[1] Typical values were measured with  $V_{CC(3V3)} = 3.3\text{ V}$ ;  $V_{CC(5V0)} = 5.0\text{ V}$ .

[2] Pin ENABLE should only change state when the DDC bus is in an idle state.

9.1 AC Waveforms

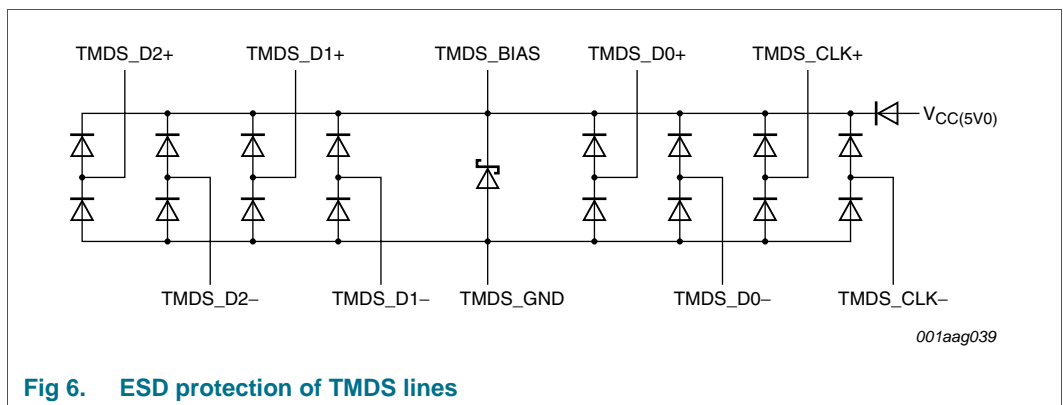




## 10. Application information

### 10.1 TMDS

To protect the TMDS lines and also to comply with the impedance requirements of the HDMI specification, the IP4778CZ38 provides ESD protection with a low capacitive load. The dominant value for the TMDS line impedance is the capacitive load to ground. The IP4778CZ38 has a capacitive load of only 0.7 pF.

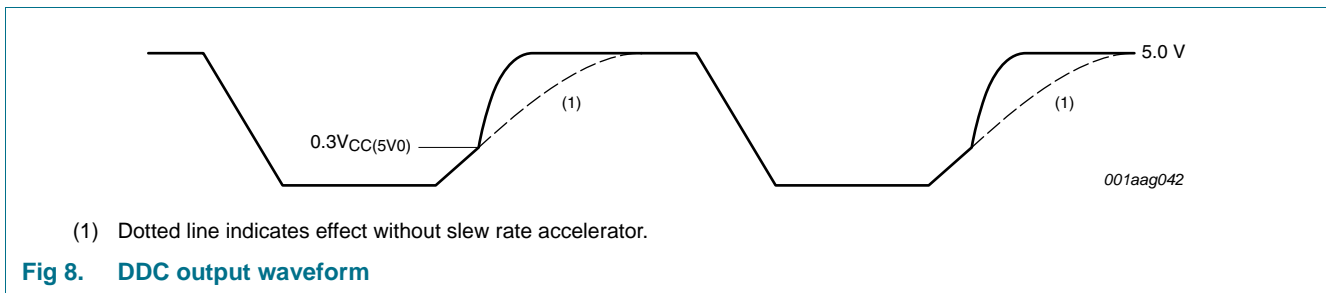
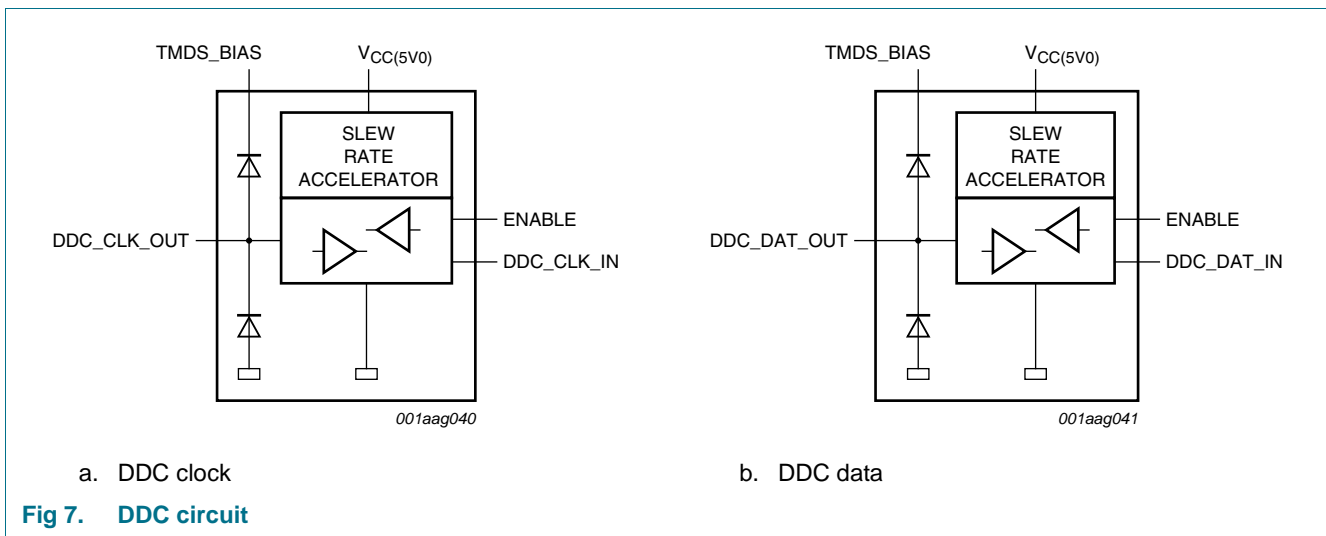


10.2 DDC circuit

The DDC-bus circuit contains full capacitive decoupling between the HDMI connector and the DDC-bus lines on the PCB. The capacitive decoupling ensures that the maximum capacitive load is within the 50 pF maximum of the HDMI specification.

The slew rate accelerator supports high capacitive load on the HDMI cable side. Various HDMI cable suppliers produce low-cost and long (typically 25 m) HDMI cables with a capacitive load of up to 6 nF.

The slew rate accelerator boosts the DDC signal independent of which side of the bus is releasing the signal. The DDC module provides a level shifting and a multiplex option which is enabled by the ENABLE signal.



### 10.3 Hot plug driver circuit

The IP4778CZ38 includes a hot plug driver circuit that simplifies the hot plug application. The circuit can be connected directly to GPIO pins.

The hot plug control input is actively pulled LOW to ensure that at system standby or start-up, the hot plug signal is HIGH even if a GPIO pin is in a 3-state condition.

For correct CEC handling, it is essential that the hot plug signal is at HIGH-level in Standby mode. The HDMI source requires a hot plug signal so that it can read out the EDID information to initiate a proper start-up CEC sequence.

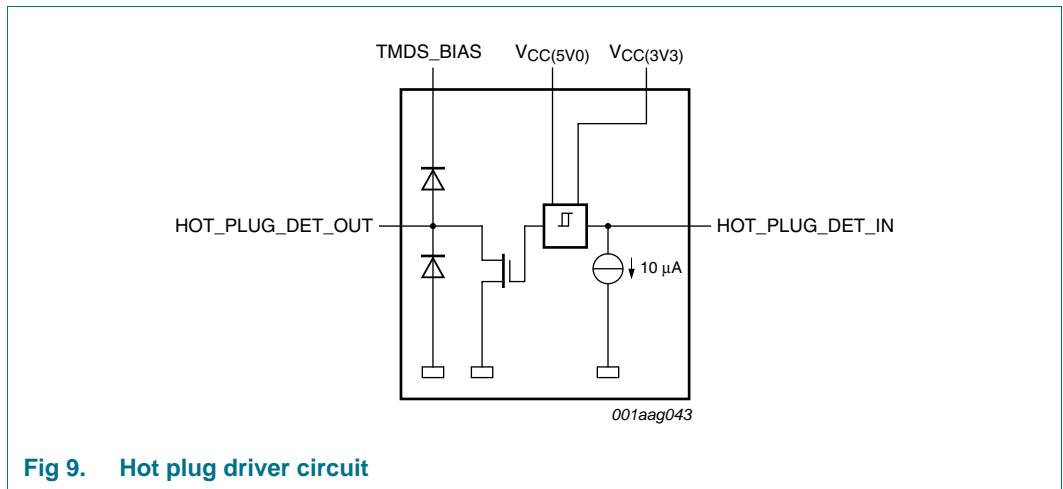


Fig 9. Hot plug driver circuit

### 10.4 CEC

The CEC signal can generate distortions caused by signal ringing in a 1 kHz domain. The CEC slew rate limiter ensures that a signal does not ring independently of the CEC slave that is releasing the signal.

A MOSFET transistor implements the backdrive protection which blocks signals during a power-down state.

The slew rate of the CEC bus is controlled by a slew rate that is defined independently of the load (ohmic and capacitive) at the CEC bus.

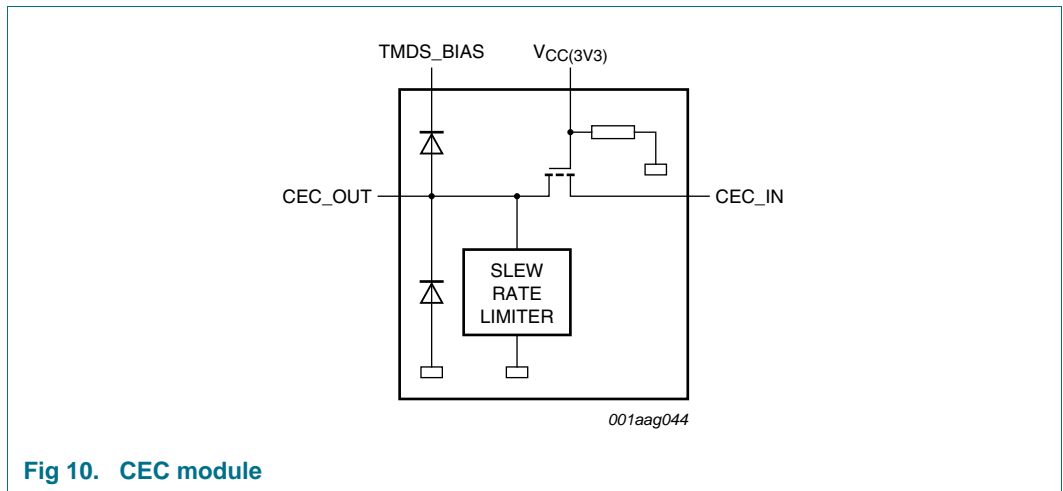


Fig 10. CEC module

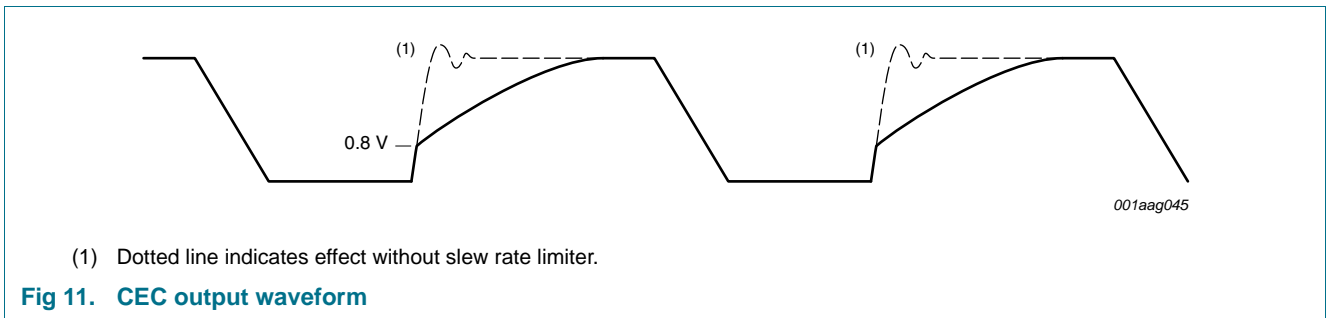
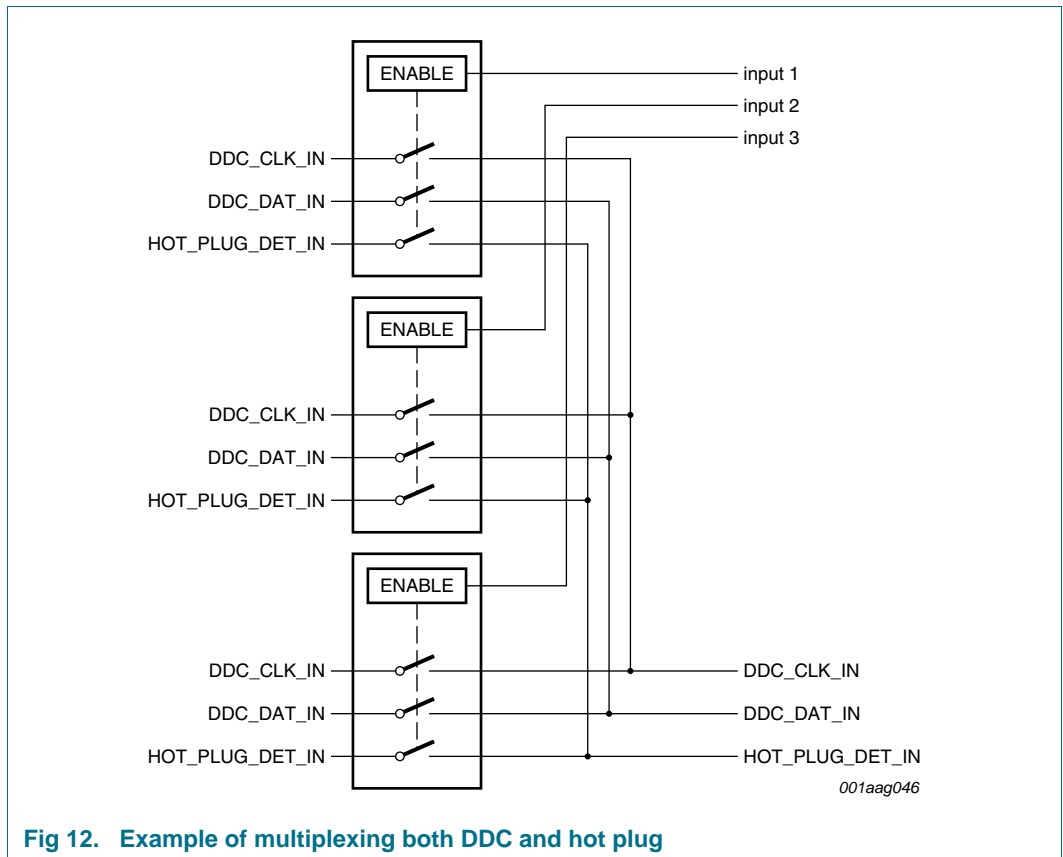


Fig 11. CEC output waveform

### 10.5 Multiplexing

Up to four HDMI interface ports can exist on an HDMI receiver. The DDC and hot plug signals are both needed to support various HDMI connectors, multiplexing and switching of the TMDS lines. The CEC bus has to remain functional in order to detect activity such as a brake in support.



**Fig 12. Example of multiplexing both DDC and hot plug**

The combination of a TMDS switch and the IP4778CZ38 is a cost-effective way to attain various HDMI ports by using a single input HDMI receiver device. The ENABLE signal activates the HDMI DDC and hot plug lines at the port that is selected by the system controller.



### 10.6 Backdrive protection

The HDMI contains various signals which can partly supply current into an HDMI device that is powered down.

Typically, the DDC lines and the CEC signals can force 5 V into the switched-off device. The IP4778CZ38 ensures that at power-down, the critical signals are blocked to prevent any damage to the HDMI sink and HDMI source.

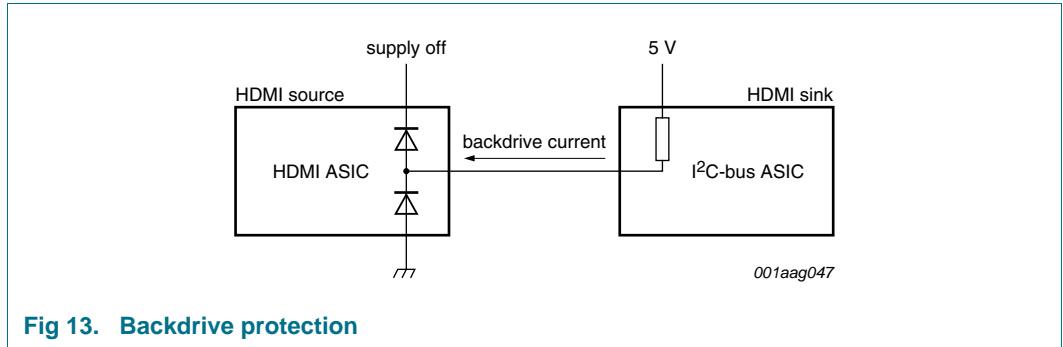


Fig 13. Backdrive protection

10.7 Application schematic

Figure 14 shows a typical application where the IP4778CZ38 provides a simplified interface to an HDMI port. This application requires only a few external components to adapt the HDMI port to the parameters of the HDMI receiver device or HDMI multiplexer.

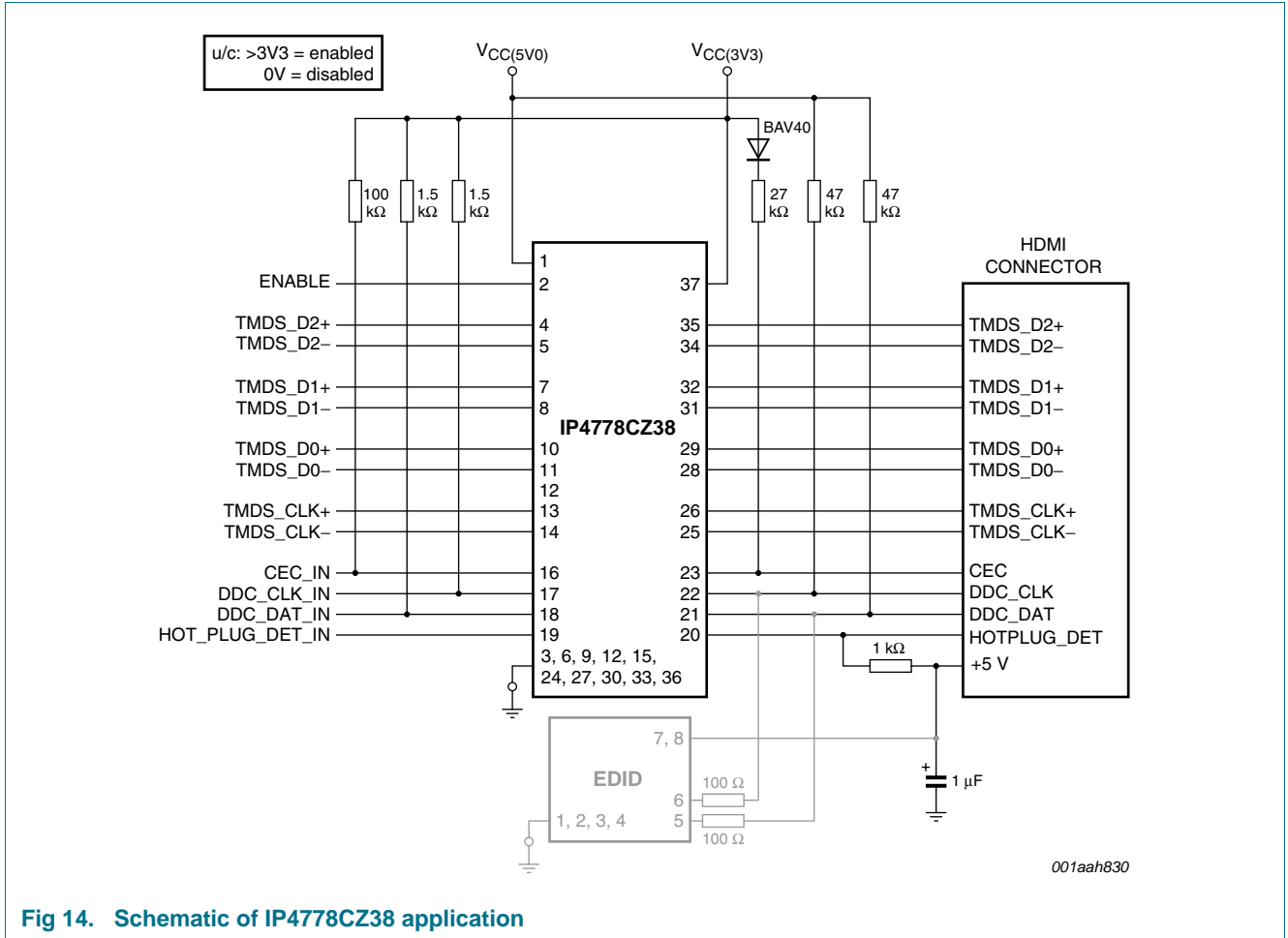


Fig 14. Schematic of IP4778CZ38 application

10.8 Typical application

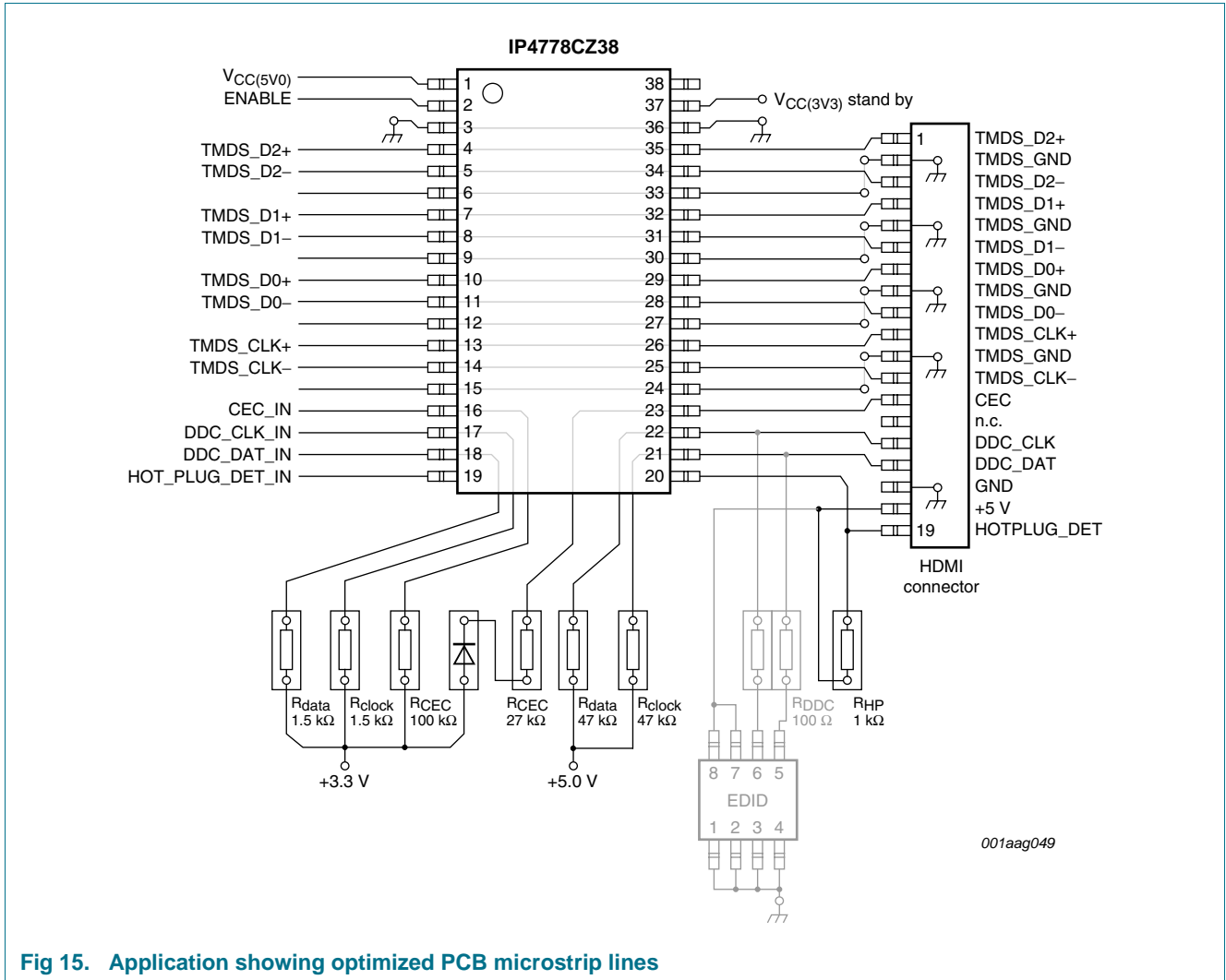


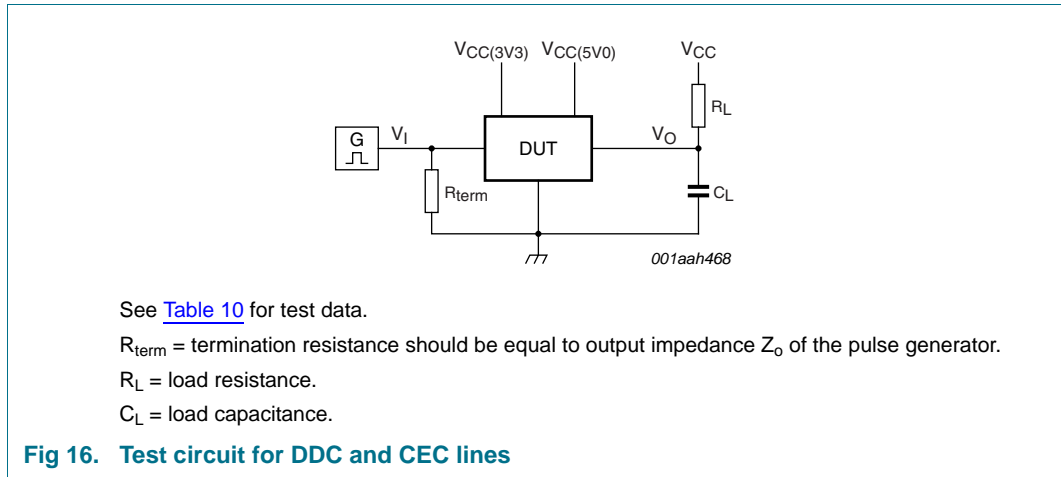
Fig 15. Application showing optimized PCB microstrip lines

This application ensures that the EDID (stored in the EEPROM) can be read out in Standby mode, even if long cables are used, to guarantee correct CEC wake-up handling. To wake up the system from Standby to normal operation, the HDMI source has to first read the EDID in order to hand over the port ID via the CEC protocol. This ensures that the HDMI starts up and switches to the correct HDMI port to display the HDMI source which initiates the CEC wake-up sequence.

The CEC bus is enabled by activating the  $V_{CC(3V3)}$  standby supply.

The RF routing optimized pin position variant allows optimum design layout of the RF routing microstrips to ensure that the impedance of the TMDS lines remain within the specification limits. Part of the microstrips comprise a solid ground plane which is located beneath the device.

## 11. Test information



**Table 10. Test data**

Test	$R_L$	$C_L$	$V_{CC}$
DDC lines	1.35 k $\Omega$	50 pF	$V_{CC(5V0)}$
CEC line	27 k $\Omega$	50 pF	$V_{CC(3V3)}$

## 12. Package outline

TSSOP38: plastic thin shrink small outline package; 38 leads; body width 4.4 mm; lead pitch 0.5 mm

SOT510-1

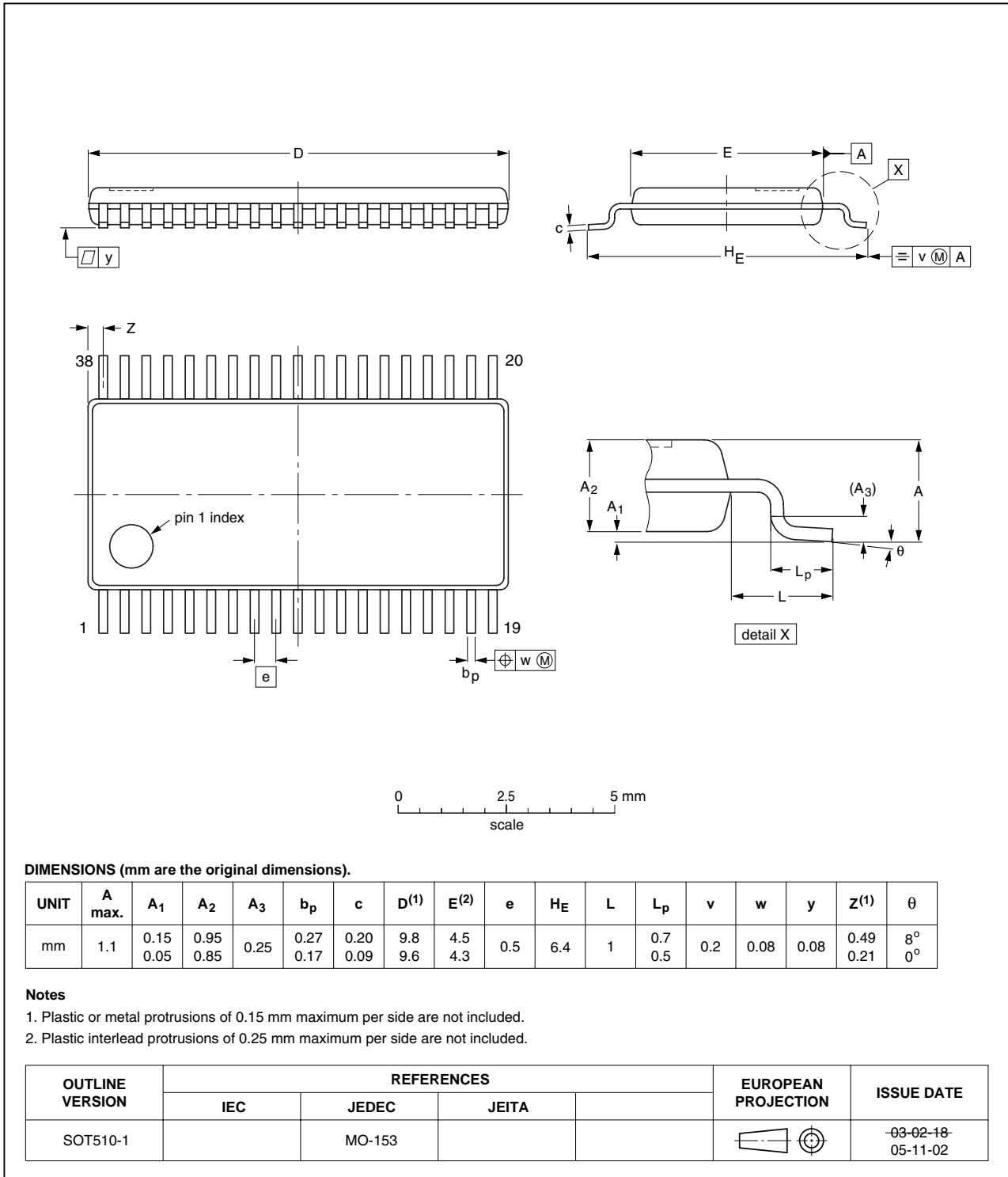


Fig 17. Package outline SOT510-1 (TSSOP38)

## 13. Soldering of SMD packages

This text provides a very brief insight into a complex technology. A more in-depth account of soldering ICs can be found in Application Note *AN10365 "Surface mount reflow soldering description"*.

### 13.1 Introduction to soldering

Soldering is one of the most common methods through which packages are attached to Printed Circuit Boards (PCBs), to form electrical circuits. The soldered joint provides both the mechanical and the electrical connection. There is no single soldering method that is ideal for all IC packages. Wave soldering is often preferred when through-hole and Surface Mount Devices (SMDs) are mixed on one printed wiring board; however, it is not suitable for fine pitch SMDs. Reflow soldering is ideal for the small pitches and high densities that come with increased miniaturization.

### 13.2 Wave and reflow soldering

Wave soldering is a joining technology in which the joints are made by solder coming from a standing wave of liquid solder. The wave soldering process is suitable for the following:

- Through-hole components
- Leaded or leadless SMDs, which are glued to the surface of the printed circuit board

Not all SMDs can be wave soldered. Packages with solder balls, and some leadless packages which have solder lands underneath the body, cannot be wave soldered. Also, leaded SMDs with leads having a pitch smaller than ~0.6 mm cannot be wave soldered, due to an increased probability of bridging.

The reflow soldering process involves applying solder paste to a board, followed by component placement and exposure to a temperature profile. Leaded packages, packages with solder balls, and leadless packages are all reflow solderable.

Key characteristics in both wave and reflow soldering are:

- Board specifications, including the board finish, solder masks and vias
- Package footprints, including solder thieves and orientation
- The moisture sensitivity level of the packages
- Package placement
- Inspection and repair
- Lead-free soldering versus SnPb soldering

### 13.3 Wave soldering

Key characteristics in wave soldering are:

- Process issues, such as application of adhesive and flux, clinching of leads, board transport, the solder wave parameters, and the time during which components are exposed to the wave
- Solder bath specifications, including temperature and impurities

### 13.4 Reflow soldering

Key characteristics in reflow soldering are:

- Lead-free versus SnPb soldering; note that a lead-free reflow process usually leads to higher minimum peak temperatures (see [Figure 18](#)) than a SnPb process, thus reducing the process window
- Solder paste printing issues including smearing, release, and adjusting the process window for a mix of large and small components on one board
- Reflow temperature profile; this profile includes preheat, reflow (in which the board is heated to the peak temperature) and cooling down. It is imperative that the peak temperature is high enough for the solder to make reliable solder joints (a solder paste characteristic). In addition, the peak temperature must be low enough that the packages and/or boards are not damaged. The peak temperature of the package depends on package thickness and volume and is classified in accordance with [Table 11](#) and [12](#)

**Table 11. SnPb eutectic process (from J-STD-020C)**

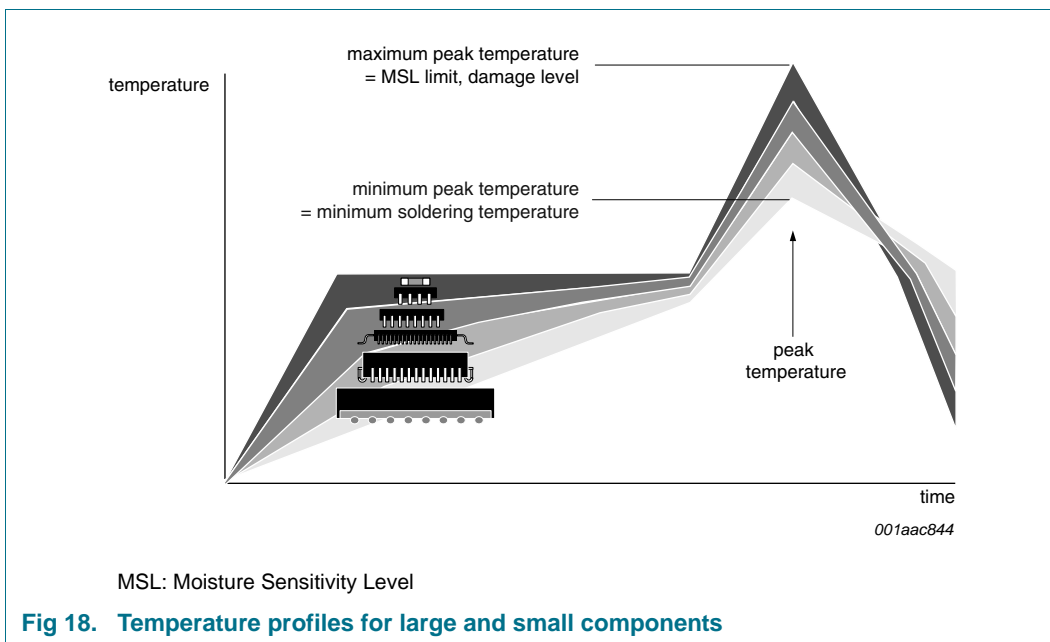
Package thickness (mm)	Package reflow temperature (°C)	
	Volume (mm <sup>3</sup> )	
	< 350	≥ 350
< 2.5	235	220
≥ 2.5	220	220

**Table 12. Lead-free process (from J-STD-020C)**

Package thickness (mm)	Package reflow temperature (°C)		
	Volume (mm <sup>3</sup> )		
	< 350	350 to 2000	> 2000
< 1.6	260	260	260
1.6 to 2.5	260	250	245
> 2.5	250	245	245

Moisture sensitivity precautions, as indicated on the packing, must be respected at all times.

Studies have shown that small packages reach higher temperatures during reflow soldering, see [Figure 18](#).



For further information on temperature profiles, refer to Application Note AN10365 “Surface mount reflow soldering description”.

## 14. Abbreviations

Table 13. Abbreviations

Acronym	Description
CEC	Consumer Electronics Control
DDC	Data Display Channel
DVD	Digital Video Disk
DVI	Digital Video Interface
EDID	Extended Display Identification Data
EEPROM	Electrically Erasable Programmable Read-Only Memory
ESD	ElectroStatic Discharge
FET	Field-Effect Transistor
GPIO	General Purpose Input/Output
HDMI	High-Definition Multimedia Interface
MOSFET	Metal Oxide Semiconductor Field Effect Transistor
RoHS	Restriction of Hazardous Substances
TMDS	Transition Minimized Differential Signaling

## 15. Glossary

**HDMI sink** — Device which receives HDMI signals e.g. a TV set.

**HDMI source** — Device which transmit HDMI signal e.g. a DVD player.



## 16. Revision history

Table 14. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
IP4778CZ38 v.3	20110331	Product data sheet	-	IP4778CZ38 v.2
Modifications:		<ul style="list-style-type: none"><li>• <a href="#">Section 1 "General description"</a>: updated.</li><li>• <a href="#">Section 2 "Features and benefits"</a>: updated.</li><li>• <a href="#">Section 14 "Abbreviations"</a>: updated.</li><li>• <a href="#">Section 17 "Legal information"</a>: updated.</li></ul>		
IP4778CZ38 v.2	20090212	Product data sheet	-	IP4778CZ38 v.1
IP4778CZ38 v.1	20080410	Objective data sheet	-	-

## 17. Legal information

### 17.1 Data sheet status

Document status <sup>[1][2]</sup>	Product status <sup>[3]</sup>	Definition
Objective [short] data sheet	Development	This document contains data from the objective specification for product development.
Preliminary [short] data sheet	Qualification	This document contains data from the preliminary specification.
Product [short] data sheet	Production	This document contains the product specification.

[1] Please consult the most recently issued document before initiating or completing a design.

[2] The term 'short data sheet' is explained in section "Definitions".

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