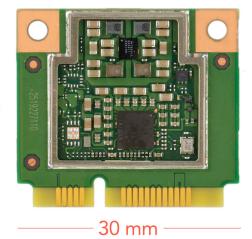
# Coral

# Mini PCIe Accelerator Datasheet

Version 1.0

26.8mm





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#### **Features**

- Google Edge TPU ML accelerator
- Standard Half-Mini PCle card
- Supports Debian Linux and other variants on host CPU

Photo shows the card with shield can removed

## Overview

The Coral Mini PCle Accelerator is a PCle module that brings the Edge TPU coprocessor to existing systems and products.

The Edge TPU is a small ASIC designed by Google that provides high performance ML inferencing with low power requirements: it's capable of performing 4 trillion operations (tera-operations) per second (TOPS), using 0.5 watts for each TOPS (2 TOPS per watt). For example, it can execute state-of-the-art mobile vision models such as MobileNet v2 at 400 FPS, in a power efficient manner. This on-device processing reduces latency, increases data privacy, and removes the need for constant high-bandwidth connectivity.

The Mini PCle Accelerator is a half-size Mini PCle card designed to fit in any standard Mini PCle slot. This form-factor enables easy integration into ARM and x86 platforms so you can add local ML acceleration to products such as embedded platforms, mini-PCs, and industrial gateways.

# Requirements

The Coral Mini PCle Accelerator must be connected to a host computer with the following specifications:

- Any Linux computer with a compatible Mini PCle module slot
  - Debian 6.0 or higher, or any derivative thereof (such as Ubuntu 10.0+)
  - System architecture of either x86-64 or ARM32/64 with ARMv8 instruction set

For software required on the host, see the **software and operation section**.

# **Specifications**

The design of the Mini PCle Accelerator adheres to the PCl-SIG's electromechanical specification for the PCl Express Mini Card. For in-depth mechanical details, refer to that specification.

Table 1. Mini PCle Accelerator technical specs

Physical specifications				
Dimensions	30 x 26.8 x 2.5 mm			
Weight	3.6 g			
Host interface				
Hardware interface	Half-Mini PCle card			
Serial interface	PCle Gen2 x1			
Operating voltage				
DC supply	3.3V +/- 10 %			
Environmental reliability				
Temperature <sup>1</sup>	-40 ~ 85° C (storage) -20 ~ 70° C (operating)			
Relative humidity	0 ~ 100% (non-condensing)			
Mechanical reliability				
Op-shock	100 G, 11ms (persistent) 1000 G, 0.5 ms (stress) 1000 G, 1.0 ms (stress)			
Op-vibe (random)	0.5 Grms, 5 - 500 Hz (persistent) 3 Grms, 5 - 800 Hz (stress)			
Op-vibe (sinusoidal)	0.5 Grms, 5 - 500 Hz (persistent) 3 Grms, 5 - 800 Hz (stress)			
Compliance				
Countries <sup>2</sup>	Unit shipped as component. Certification/compliance to be done by customer.			
ESD <sup>3</sup>	1kV HBM, 250V CDM			

### **Dimensions**

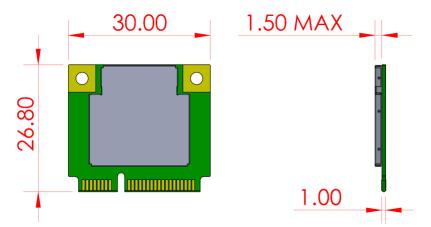
Total size: 30 x 26.80 x 2.5 mm

• PCB size: 30 x 26.80 x 1.0 mm

• Top-side component height (max): 1.5 mm

• Bottom-side component height: 0 mm

For in-depth mechanical specs, refer to the PCI Express Mini Card Electromechanical Specification.



**Figure 1.** Mini PCle Accelerator dimensions (in millimeters)

# Power specifications

The Mini PCle Accelerator is powered by 3.3V as shown in the **connector pinout**. Typical power consumption depends on the model architecture and operating parameters, but some sample power consumption is shown in table 2. See the below section for information about the different **operating frequencies**.

Table 2. Mini PCle Accelerator typical power consumption

	Low operating frequency	Nominal operating frequency	Max operating frequency
MobileNet v2	0.6 W (7.1 ms @ 141 fps)	0.9 W (3.9 ms @ 256 fps)	1.4 W (2.4 ms @ 416 fps)
Inception v3	0.5 W (58.7 ms @ 17 fps)	0.6 W (51.7 ms @ 19.3 fps)	0.7 W (48.2 ms @ 20.7 fps)

<sup>&</sup>lt;sup>1</sup> Operational temperature range depends on the **power consumption** and **thermal management** in your system.

<sup>&</sup>lt;sup>2</sup> We can provide certification example to demonstrate that a reasonably designed system meets certification requirements.

<sup>&</sup>lt;sup>3</sup> Always handle in static safe environment.

# Thermal limit and operating frequency

The thermal resistance and max allowed temperature of the Edge TPU stack-up is as follows:

- Thermal resistance (junction to top of shield can): 11 °C/W
- Maximum Edge TPU junction temperature: 100 °C

The Mini PCle Accelerator does not include a thermal solution to dissipate heat from the system. In order to sustain maximum performance from the Edge TPU, it's important that you design your system so the Edge TPU operates well below the maximum Edge TPU temperature. If the Edge TPU gets too hot, it slowly reduces the operating frequency and may reset to avoid permanent damage.

The PCle driver includes a power throttling mechanism (also known as dynamic frequency scaling) and an emergency shutdown mechanism, based on temperature readings from the Edge TPU. By default, this system checks the Edge TPU die temperature every 5 seconds and responds as follows:

- If the Edge TPU is below 85°C, continue at the "maximum" operating frequency.
- If the Edge TPU reaches 85°C, reduce the operating frequency 50% (from "maximum" to "normal").
- If the Edge TPU reaches 90°C, reduce the operating frequency another 50% (from "normal" to "low").
- If the Edge TPU reaches 95°C, reduce the operating frequency yet another 50% (from "low" to "lowest").
- If the Edge TPU reaches 100°C, reset the Edge TPU.

By reducing the operating frequency, the Edge TPU's inferencing speed becomes slower, but it also consumes less power and hopefully avoids reaching the hardware reset threshold.

As long as the Edge TPU does not reset and the Edge TPU temperature returns to lower levels, the system restores the operating frequency in the reverse manner—ultimately returning to the maximum operating frequency when the Edge TPU is below 85°C.

# Connector pinout

Table 3. Mini PCle Accelerator connector pinout

Top side pins		Bottom side pins	
Signal	Pin	Pin	Signal
NC	1	2	3.3V
NC	3	4	GND
NC	5	6	NC

Top side pins		Bottom side pins				
Signal	Pin	Pin	Signal			
CLKREQ# (3.3V)	7	8	NC			
GND	9	10	NC			
REFCLK-	11	12	NC			
REFCLK+	13	14	NC			
GND	15	16	NC			
Key slot						
NC	17	18	GND			
NC	19	20	NC			
GND	21	22	PERST# (3.3V)			
PERn0	23	24	3.3V			
PERp0	25	26	GND			
GND	27	28	NC			
GND	29	30	NC			
PETn0	31	32	NC			
РЕТр0	33	34	GND			
GND	35	36	NC			
GND	37	38	NC			
3.3V	39	40	GND			
3.3V	41	42	NC			
GND	43	44	NC			
NC	45	46	NC			
NC	47	48	NC			
NC	49	50	GND			
NC	51	52	3.3V			

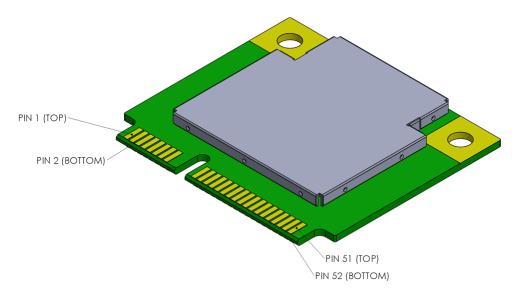


Figure 2. Mini PCle Accelerator pin positions

# Software and operation

The host system must be running Debian Linux 6.0 or higher, or any derivative thereof, and have the Edge TPU runtime and API library installed.

The PCle kernel driver is already upstreamed to kernel.org with source, since version 4.19. For earlier versions, dkms driver is available via gasket-dkms deb package at https://packages.cloud.google.com/apt coral-edgetpu-stable main.

To learn how to create models and run inferences the Edge TPU, read TensorFlow models on the Edge TPU.