

# Google Coral Board



## 1 Overview

The *Google Coral Board* by X-CITE is a compact device that combines the abilities of a 4.9G and 5G connectivity enabler and a vigorous edge computing device with the possibility to attach peripheral sensor modules for applying advanced 5G use cases.

### 1.1 Connectivity Stack

The *Google Coral Board* provides a wide set of connectivity options. It supports cellular technologies such as 3G, 4G and 5G, but is also able to connect to *Ethernet* or *Wi-Fi* and *BLE*. As the *Google Coral Board* is equipped with a *Board-2-Board (B2B)* connector, peripheral connectivity modules can be attached to the device.

### 1.2 Sensing Abilities

As the *Google Coral Board* is equipped with a *Board-2-Board (B2B)* connector, peripheral modules can be attached to the device. By attaching our in-house developed *Sensor Module*, the *Google Coral Board* will be able to measure the environmental parameters that it provides. Moreover, using the available SDI-12, I2C and analog interfaces of the *Google Coral Board*, third party sensors can be attached to the device.

## 1.3 Edge Computing

The *Google Coral Board* provides high processing power enabled by the embedded *Google Edge TPU Processor*, along with its *8GB Memory* and *1GB Low Power RAM*.

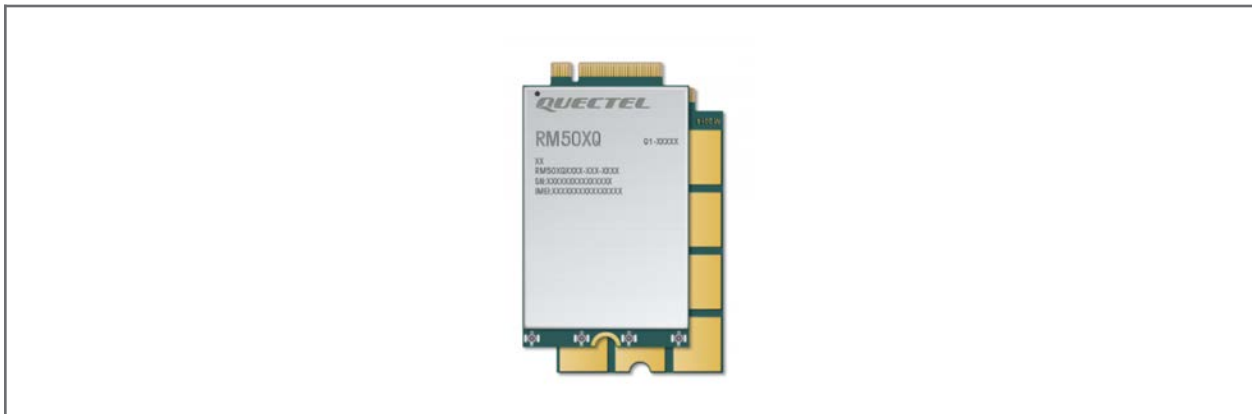
## 1.3 Other Features

The *Google Coral Board* is equipped with USB-A, USB-C, USB 2.0, USB 3.0 and HDMI data and power supply, along with an external power supply connector. Additional camera, SIM and SD card connectors are available. The enclosure of the device is fully IP65 compliant.

## 2 5G Module - Quectel RM500Q-GL

The *Quectel RM500Q-GL* is a 5G module optimized specially for IoT/eMBB applications. Adopting the 3GPP Release 15 LTE technology, it supports both 5G NSA and SA modes.

**Figure 1** Quectel RM500Q-GL module that is used in the *Google Coral Board*



The global version RM500Q-GL nearly covers all the mainstream carriers worldwide. The module supports Qualcomm® IZat™ location technology Gen9C Lite (GPS, GLONASS, BeiDou/Compass and Galileo). The integrated GNSS receiver greatly simplifies the product design and provides quicker, more accurate and more dependable positioning capability.

A rich set of Internet protocols, industry-standard interfaces and abundant functionalities (USB and PCIe drivers for Windows, Linux and Android) extend the applicability of the module to a wide range of eMBB and IoT applications such as industrial router, home gateway, STB, industrial laptop, consumer laptop, industrial PDA, rugged tablet PC, video surveillance and digital signage. Detailed specifications are listed below.

Quectel RM500Q-GL		
<b>Region/Operator</b>	Global (Except for United States)	
<b>Dimensions (mm)</b>	30.0 x 52.0 x 2.3	
<b>Weight (g)</b>	8.7	
Temperature Range		
<b>Operation Temperature</b>	-30°C to +70°C	
<b>Extended Temperature</b>	-40°C to +85°C	
Frequency Bands		
<b>5G</b>	<b>5G NR</b>	3GPP Release 15 NSA/SA operation, Sub-6 GHz
	<b>5G NR NSA</b>	n38/n41/n77/n78/n79
	<b>5G NR SA</b>	n1/n2/n3/n5/n7/n8/n12/n20/n25/n28/n38/n40/n41/n48*/n66/n71/n77/n78/n79
	<b>MIMO</b>	DL: 4 × 4 MIMO on n1/n2/n3/n7/n25/n38/n40/n41/n48*/n66/n77/n78/n79 UL: 2 × 2 MIMO on n41/n77/n78/n79
<b>LTE</b>	<b>LTE Category</b>	DL Cat 16/ UL Cat 18
	<b>LTE-FDD</b>	B1/B2/B3/B4/B5/B7/B8/B12/B13/B14/B17/B18/B19/B20/B25/B26/B28/B29/B30/B32/B66/B71
	<b>LTE-TDD</b>	B34/B38/B39/B40/B41/B42/B43/B48
	<b>LAA</b>	B46
	<b>DL 4x4 MIMO</b>	B1/B2/B3/B4/B7/B25/B30/B32/B34/B38/B39/B40/B41/B42/B43/B48/B66
<b>UMTS</b>	<b>WCDMA</b>	B1/B2/B3/B4/B5/B8/B19
<b>GNSS</b>		GPS/GLONASS/BeiDou (Compass)/Galileo
Certifications		
<b>Regulatory</b>		Global: GCF Europe: CE China: SRRC/CCC/NAL Korea: KC Australia/New Zealand: RCM
<b>Carrier</b>		China: China Telecom/China Mobile/China Unicom/KT*/SKT*/LGU+*
<b>Others</b>		RoHS/WHQL
Data Rate (Max.)		
<b>5G SA Sub-6</b>		DL 2.1 Gbps; UL 900 Mbps
<b>5G NSA Sub-6</b>		DL 2.5 Gbps; UL 650 Mbps

<b>LTE</b>	DL 1.0 Gbps; UL 200 Mbps
<b>WCDMA</b>	DL 42 Mbps; UL 5.76 Mbps
<b>Interfaces</b>	
<b>(U)SIM</b>	x 2
<b>USB 2.0</b>	x 1
<b>USB 3.0/3.1</b>	x 1
<b>PCIe 3.0</b>	x 1
<b>PCM*</b>	x 1
<b>Antenna</b>	x 4
<b>Voice</b>	
<b>VoLTE</b>	Digital Audio and VoLTE (Voice over LTE) (Optional)
<b>Enhanced Features</b>	
<b>eSIM* (Optional)</b>	Supported
<b>DTMF*</b>	Supported
<b>DFOTA*</b>	Supported
<b>(U)SIM Card Detection</b>	Supported
<b>Drivers</b>	
<b>USB Serial Driver</b>	Windows 7/8/8.1/10; Linux 2.6–5.4; Android 4.x/5.x/6.x/7.x/8.x/9.x/10
<b>GNSS Driver</b>	Android 4.x/5.x/6.x/7.x/8.x/9.x/10
<b>RIL Driver</b>	Android 4.x/5.x/6.x/7.x/8.x/9.x/10
<b>NDIS Driver</b>	Windows 7/8/8.1/10
<b>MBIM Driver</b>	Windows 10; Linux 3.18–5.4
<b>GobiNet Driver</b>	Linux 2.6–5.4
<b>QMI_WWAN Driver</b>	Linux 3.4–5.4
<b>Electrical Features</b>	
<b>Supply Voltage Range</b>	3.135–4.4 V, typical 3.7 V
<b>Power Consumption</b>	70 $\mu$ A @ Power down 5 mA @ Sleep 39 mA @ USB 2.0, Idle

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64 mA @ USB 3.0, Idle

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## 3 ML Module - Google Coral System on Module

The System on Module (SoM) is a single-board computer that's ideal for performing fast machine learning (ML) inferencing in a small form factor combined with custom PCB hardware.

**Figure 19** Google Coral SoM within the *Google Coral Board*



The SoM provides a fully-integrated system, including NXP's iMX 8M system-on-chip (SoC), eMMC memory, LPDDR4 RAM, Wi-Fi, and Bluetooth, but its unique power comes from Google's Edge TPU coprocessor. The Edge TPU is a small ASIC designed by Google that is 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 almost 400 FPS, in a power efficient manner. Moreover, TensorFlow Lite models can be compiled to run on the Edge TPU + high-accuracy custom image classification models with AutoML Vision Edge can be easily built and deployed.

The baseboard provides all the peripheral connections that are needed to prototype a project, including USB 2.0/3.0 ports, DSI display interface, CSI-2 camera interface, Ethernet port, speaker terminals, and a 40-pin I/O header. Detailed specifications are listed below.

### Overall Specifications

<b>CPU</b>	NXP i.MX 8M SoC (quad Cortex-A53, Cortex-M4F)
<b>GPU</b>	Integrated GC7000 Lite Graphics
<b>ML accelerator</b>	Google Edge TPU coprocessor: 4 TOPS (int8); 2 TOPS per watt
<b>RAM</b>	1 GB LPDDR4 (option for 2 GB or 4 GB in future releases)
<b>Flash memory</b>	8 GB eMMC, MicroSD slot
<b>Wireless</b>	Wi-Fi 2x2 MIMO (802.11b/g/n/ac 2.4/5GHz) and Bluetooth 4.2
<b>USB</b>	Type-C OTG; Type-C power; Type-A 3.0 host; Micro-B serial console
<b>LAN</b>	Gigabit Ethernet port
<b>Audio</b>	3.5mm audio jack (CTIA compliant); Digital PDM microphone (x2); 2.54mm 4-pin terminal for stereo speakers
<b>Video</b>	HDMI 2.0a (full size); 39-pin FFC connector for MIPI-DSI display (4-lane); 24-pin FFC connector for MIPI-CSI2 camera (4-lane)
<b>GPIO</b>	3.3V power rail; 40 - 255 ohms programmable impedance; ~82 mA max current
<b>Power</b>	5V DC (USB Type-C)
<b>Dimensions</b>	88 mm x 60 mm x 24mm
<b>Availability</b>	Australia, Japan, New Zealand, Taiwan, European Union (except France, Czech Republic), Ghana, Hong Kong, India, Oman, Philippines, Singapore, South Korea, Thailand, United States
<b>Main system-on-chip (i.MX8M)</b>	
<b>Arm Cortex-A53 MPCore platform</b>	<p>Quad symmetric Cortex-A53 processors:</p> <ul style="list-style-type: none"> <li>• 32 KB L1 Instruction Cache</li> <li>• 32 KB L1 Data Cache</li> <li>• Support L1 cache RAMs protection with parity/ECC</li> </ul> <p>Support of 64-bit Armv8-A architecture:</p> <ul style="list-style-type: none"> <li>• 1 MB unified L2 cache</li> <li>• Support L2 cache RAMs protection with ECC</li> <li>• Frequency of 1.5 GHz</li> </ul>
<b>Arm Cortex-M4 core platform</b>	<p>16 KB L1 Instruction Cache 16 KB L1 Data Cache 256 KB tightly coupled memory (TCM)</p>
<b>Graphic Processing Unit (GPU)</b>	<p>Vivante GC7000Lite 4 shaders 267 million triangles/sec 1.6 Gigapixel/sec 32 GFLOPs 32-bit or 64 GFLOPs 16-bit Supports OpenGL ES 1.1, 2.0, 3.0, 3.1, Open CL 1.2, and Vulkan</p>
<b>Video Processing Unit (VPU)</b>	<p>4Kp60 HEVC/H.265 main, and main 10 decoder 4Kp60 VP9 and 4Kp30 AVC/H.264 decoder (requires full system resources) 1080p60 MPEG-2, MPEG-4p2, VC-1, VP8, RV9, AVS, MJPEG, H.263 decoder</p>

<b>I/O connectivity</b>	<p>2x USB 3.0/2.0 controllers with integrated PHY interfaces          1x Ultra Secure Digital Host Controller (uSDHC) interfaces          1x Gigabit Ethernet controller with support for EEE, Ethernet AVB, and IEEE 1588          2x UART modules          2x I2C modules          2x SPI modules          16x GPIO lines with interrupt capability          4x PWM lines          Input/output multiplexing controller (IOMUXC) to provide centralized pad control          Note: The list above is the number of signals available to the baseboard (after considering SoC signals used by the SoM).</p>
<b>On-chip memory</b>	<p>Boot ROM (128 KB)          On-chip RAM (128 KB + 32 KB)</p>
<b>External memory</b>	<p>32/16-bit DRAM interface: LPDDR4-3200, DDR4-2400, DDR3L-1600          8-bit NAND-Flash          eMMC 5.0 Flash          SPI NOR Flash          QuadSPI Flash with support for XIP</p>
<b>Display</b>	<p>HDMI Display Interface:          HDMI 2.0a supporting one display up to 1080p          Upscale and downscale between 4K and HD video (requires full system resources)          20+ Audio interfaces 32-bit @ 384 kHz fs, with Time Division Multiplexing (TDM) support          SPDIF input and output          Audio Return Channel (ARC) on HDMI</p> <p>MIPI-DSI Display Interface:          MIPI-DSI 4 channels supporting one display, resolution up to 1920 x 1080 @ 60 Hz          LCDIF display controller          Output can be LCDIF output or DC display controller output</p>
<b>Audio</b>	<p>1x SPDIF input and output          2x synchronous audio interface (SAI) modules supporting I2S, AC97, TDM, and codec/DSP interfaces          1x SAI for 8 Tx channels for HDMI output audio          1x SPDIF input for HDMI ARC input</p>
<b>Camera</b>	<p>MIPI-CSI2 camera input (4-lane)</p>
<b>Security</b>	<p>Resource Domain Controller (RDC) supports four domains and up to eight regions          Arm TrustZone (TZ) architecture          On-chip RAM (OCRAM) secure region protection using OCRAM controller          High Assurance Boot (HAB)          Cryptographic acceleration and assurance (CAAM) module          Secure non-volatile storage (SNVS): Secure real-time clock (RTC)          Secure JTAG controller (SJC)</p>
<b>ML accelerator</b>	
<b>Edge TPU coprocessor</b>	<p>ASIC designed by Google that provides high performance ML inferencing for TensorFlow Lite models          Uses PCIe and I2C/GPIO to interface with the iMX 8M SoC          4 trillion operations per second (TOPS)          2 TOPS per watt</p>
<b>Memory and storage</b>	
<b>Random access memory (SDRAM)</b>	<p>1 or 4 GB LPDDR4 SDRAM (4-channel, 32-bit bus width)</p>

	1600 MHz maximum DDR clock Interfaces directly to the iMX 8M build-in DDR controller
<b>Flash memory (eMMC)</b>	8 GB NAND eMMC flash memory 8-bits MMC mode Conforms to JEDEC version 5.0 and 5.1
<b>Expandable flash (MicroSD)</b>	Meets SD/SDIO 3.0 standard Runs at 4-bits SDIO mode Supports system boot from SD card
<b>Network &amp; wireless</b>	
<b>Ethernet</b>	10/100/1000 Mbps Ethernet/IEEE 802.3 networks Reduced gigabit media-independent interface (RGMII)
<b>Wi-Fi</b>	Murata LBEE5U91CQ module: Wi-Fi 2x2 MIMO (802.11a/b/g/n/ac 2.4/5GHz) Supports PCIe host interface for W-LAN
<b>Bluetooth</b>	Murata LBEE5U91CQ module: Bluetooth 4.2 (supports Bluetooth low-energy) Supports UART interface
<b>Security</b>	
<b>Cryptographic coprocessor</b>	Microchip ATECC608A cryptographic coprocessor: Asymmetric (public/private) key cryptographic signature solution based on Elliptic Curve Cryptography and ECDSA signature protocols
<b>Baseboard</b>	
<b>Connectors</b>	40-pin I/O header (see pinout below) USB Micro-B for serial console USB 3.0 Type-A host Gigabit Ethernet 4-pin stereo terminal 3.5 mm audio jack USB Type-C power USB Type-C data HDMI 2.0a (full size) MicroSD slot MIPI DSI display (39-pin flat flex cable) MIPI CSI-2 camera (24-pin flat flex cable)