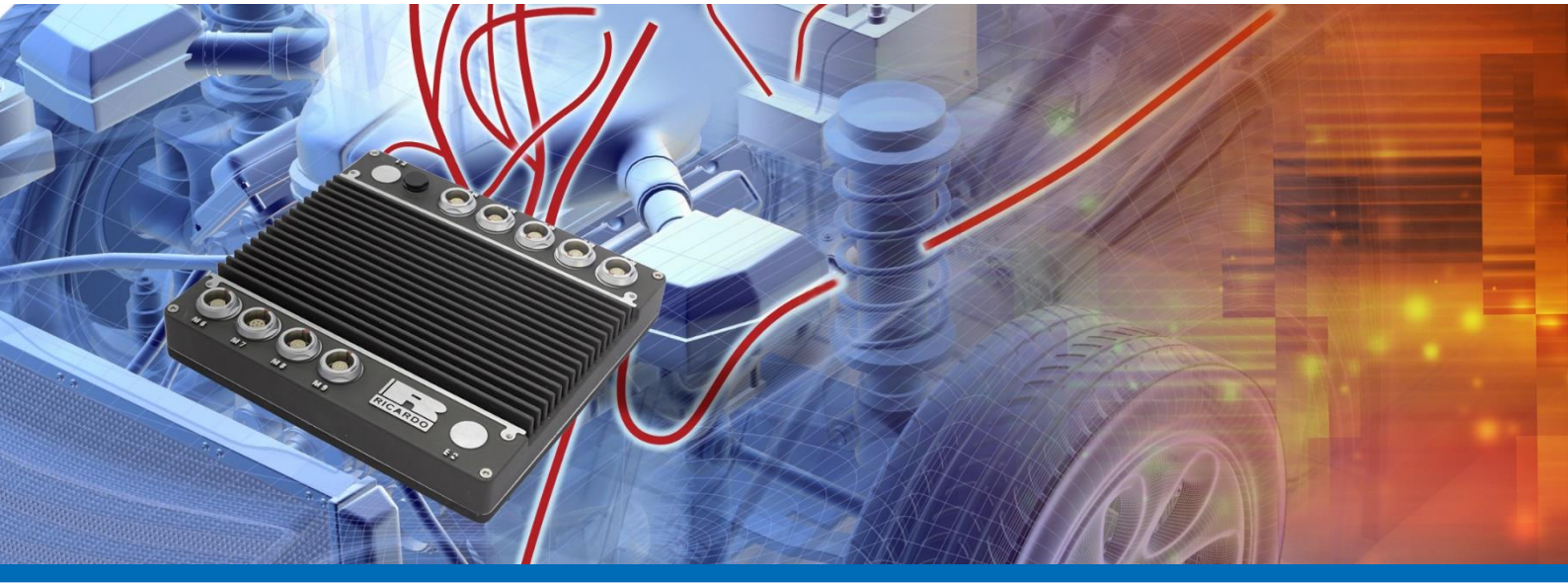


# rCube2: Advanced Rapid Prototyping Electronic Control Unit

## Overview

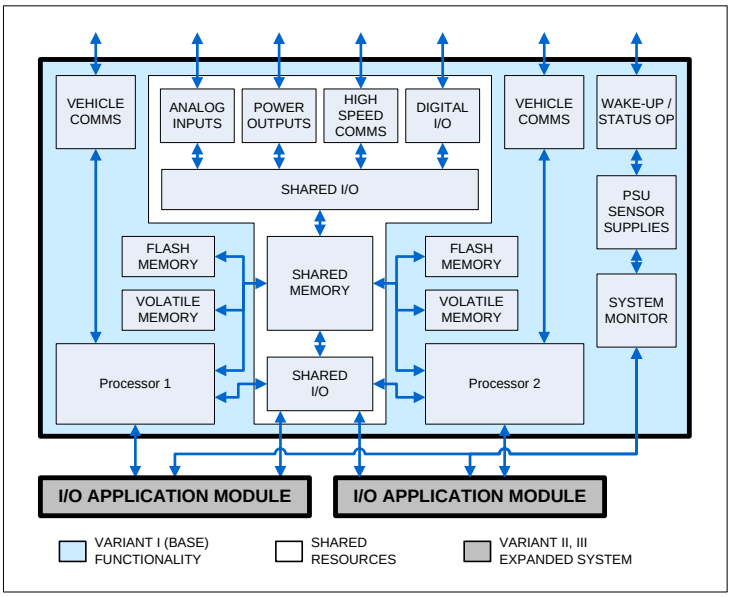
rCube2 is a rapid prototyping ECU based on AUTOSAR that enables fast and efficient development of control systems from initial concept to production. The system has been successfully used on a number of projects including Diesel/gasoline/CNG engines, transmission, hybrid powertrain control, as well as real-time 1-D gas dynamics engine model (WAVE-RT) integration into an engine control strategy.

## Key features

- Modular platform with 2 Input/Output expansion modules
- Two 32 bit Infineon processors
- Robust packaging for in-vehicle use
- LEMO® connectors
- Compatible with 12 V and 24 V
- CAN, CANopen, FlexRay, Ethernet, LIN and RS232
- Automotive specific inputs and outputs
- AUTOSAR with Simulink® integration
- OneClickBuild process from Simulink® interface
- XCP over Ethernet or CAN
- Multi-rCube2 networking support

# Base system

The rCube2 base system is called a MicroController Module (MCM) and it contains applications processors, communications interfaces (Ethernet, CAN, FlexRay, LIN, RS232) and a range of general-purpose inputs and outputs. The system is protected by an Advanced Monitoring Unit (AMU) which provides thermal and under/over voltage protection. The AMU also manages application wake-up and shutdown. CAN based, time based and periodic wake-up events are supported.




# Base embedded processing unit I/O summary

The following table summarises the input, output and communications capability of the rCube2 MicroController Module:

| Processor 1 | | Processor 2 | | Shared resources | |
|---|---|---|---|---|---|
| CAN | 4 | CAN | 4 | Analog inputs (general) | 18 |
| FlexRay | 2 | FlexRay | 2 | Thermistor inputs | 8 |
| Ethernet | 2 | Ethernet | 2 | Digital inputs (8 can be set to outputs) | 16 |
| rCube2 Morflink | 1 | rCube2 Morflink | 1 | Low side power outputs (2 A) | 4 |
| LIN | 1 | LIN | 1 | Relay power outputs (≤ 250 mA) | 4 |
| RS232 | 1 | RS232 | 1 | | |

# Core processing system

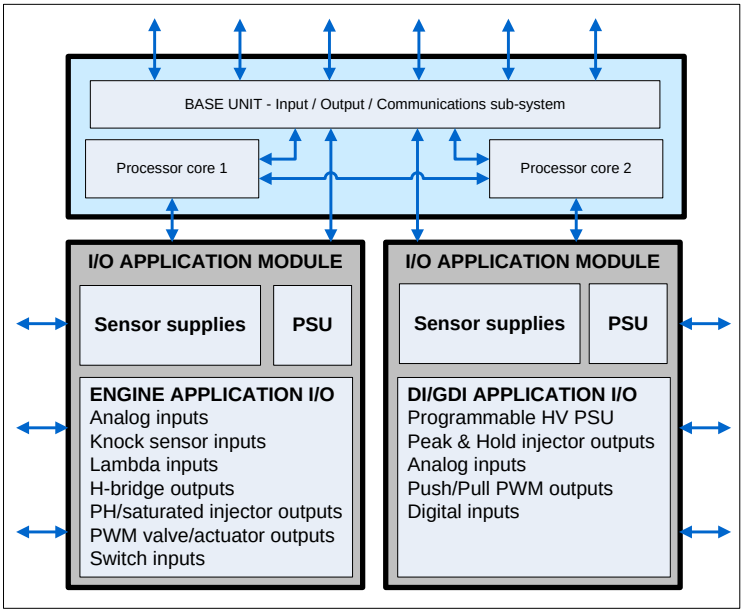
The application's core is based on two Infineon TC1797 processors. The processors are arranged in a symmetrical configuration and as such, applications can run on either one of the processors or split across both processors.

| | Performance | Memory (per processor) | |
|---|---|---|---|
| | | Volatile | Non-volatile |
| Processors (internal) | 150 MHz clock | 192 kB | 4 MB |
| External (on-board) | 75 MHz bus | 4 MB | 4 MB |

# System modularity

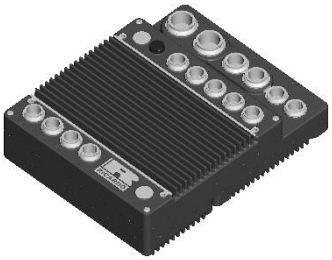
The base unit (i.e. MicroController Module) is expandable with one or two application specific input/output modules (described in separate datasheets). Ricardo supplies input/output application modules to cover a range of applications, e.g.:

- 6-cylinder gasoline and CNG injected engines
- 8-cylinder GDI and DI engines
- Single and multi-cylinder research engines
- Hybrid vehicle controllers
- Autonomous vehicle systems
- AMT and AT transmission systems
- Computationally intensive applications




| Individual variants contain the following modules | |
|---|---|
| VARIANT I | MicroController Module |
| VARIANT II | MicroController Module with one expansion module |
| VARIANT III | MicroController Module with two expansion modules |

**VARIANT I**



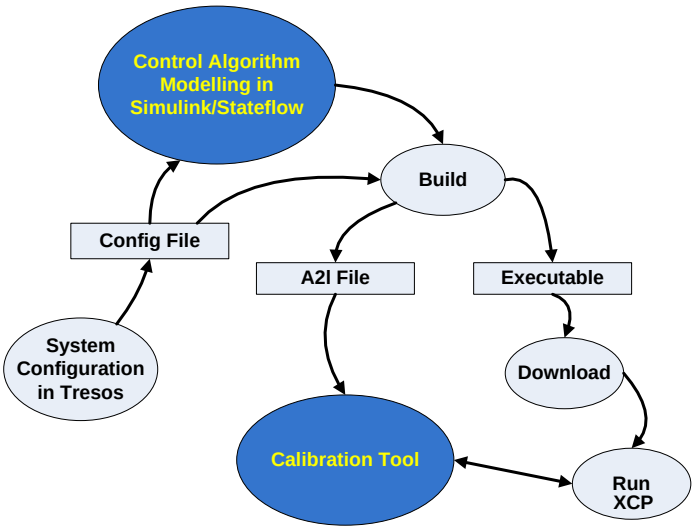
**VARIANT II**

**VARIANT III**

A full list of available modules and datasheets is available at www.ricardo.com

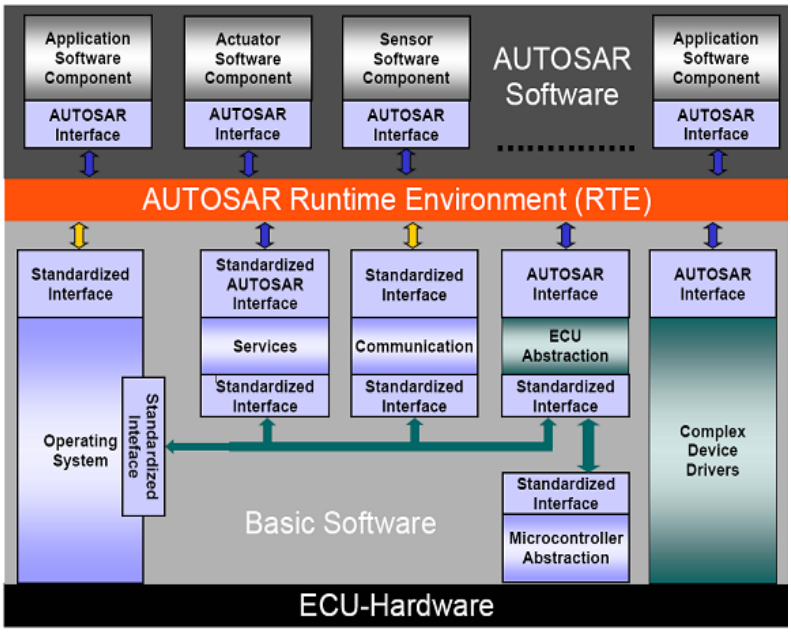
# Development environment and tools

The validated system is based on use of the Tasking Compiler for compilation and build of the downloadable files for each processor. User applications are developed as software components using MATLAB®/Simulink® with Real-Time Workshop® Embedded Coder. Ricardo supplied tools completely manage the build process (OneClickBuild) generating the download files and the ASAP2 file for calibration tools, and provide the facility for fast incremental SW build. A PCAN USB to CAN interface (not supplied) from Peak Systems GmbH is required for flashing a binary to the system.




# Embedded operating system

rCube2 uses a real-time embedded operating system with micro-controller abstraction layer components. This is supplemented by complex device drivers to support custom functionality such as high-speed communications (Ethernet, CAN, CANopen, FlexRay), engine control, actuator control, and a wide variety of measurement channels. The platform is AUTOSAR-compliant making all interaction between the platform software and the application software via the RunTime Environment (RTE) component. This allows the user to develop portable software readily transferable to a production system.




The user has access to an operating system configuration utility to perform the necessary low-level application configuration. However, Ricardo can develop pre-configured systems (templates) to suit user applications leaving the user free to concentrate on the application level development.

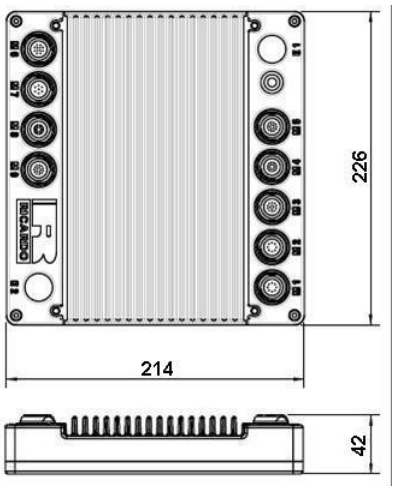
# Electrical interface/input-output set

| Power supply specifications | | |
|---|---|---|
| Typical supply voltage range | 6.0…36 V | Compliant with 24 V systems to ISO7637 part 2 |
| Reverse battery protection | built in | |
| Shutdown current | < 2 mA | System inactive |
| Standby current | < 5 mA | Periodic wake-up events programmed |
| Operating current (main module) | < 500 mA | Peripheral I/O inactive, application processors active |

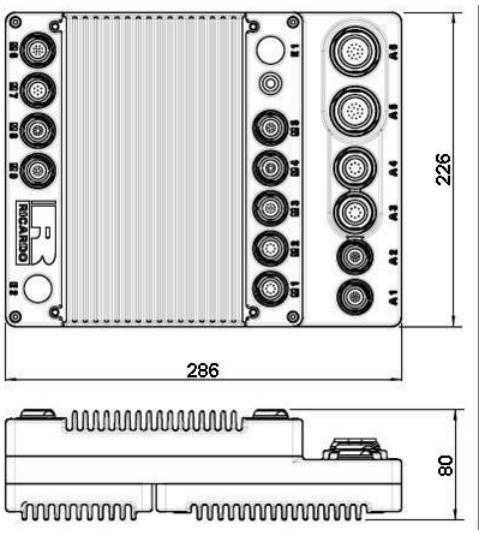
The MicroController Module without additional modules supports the following signal interfaces:

| Low power signal specifications | | |
|---|---|---|
| Analogue inputs | 18 | 14-bit resolution, ~15 kHz bandwidth, 100 kHz sampling rate, 0…5 V input range, 25 kΩ input impedance, short circuit protected |
| NTC thermistor inputs | 8 | 12-bit resolution, sampling rate ~1 Hz, short circuit protected, strobed pull-up resistance 4.7 kΩ |
| Sensor supply | 2 | 5 V, 250 mA, short circuit protected |
| Digital inputs/outputs | 8<br>OR<br>8 | Input: Configurable pull-up/down (18 kΩ/ > 100 kΩ in groups of 4), interrupt capable, short circuit protected, switching threshold: $V_{LOW_{MAX}}$ = 1.1 V, $V_{HIGH_{MIN}}$ = 4.73 V<br>Output: Battery level, 200 mA continuous, with short battery voltage protection and short circuit protection |
| Digital inputs | 8 | Configurable pull-up/down (18 kΩ/ > 100 kΩ in groups of 4), interrupt capable, short circuit protected, switching threshold: $V_{LOW_{MAX}}$ = 1.1 V, $V_{HIGH_{MIN}}$ = 4.73 V; hardware assisted detection of duty cycle of PWM and frequency |
| **Power output specifications** | | |
| Low side drive outputs | 4 | 2 A per channel, PWM capable, over-current and short circuit protection, common external pin freewheel diodes, internal diagnostics |
| Relay drive outputs | 4 | 250 mA low side drives, diagnostics feedback, short circuit protected, relay 1 driven by processor 1, relay 2 driven by processor 2, relay 3 driven by processors 1 AND 2, relay 4 driven by processor 1 OR 2 |
| Diagnostic LED outputs | 4 | High-side current-limited 25 mA output drive with short circuit protection, power supply, system monitor, processor 1 and processor 2 to indicate status |
| **Serial communications** | | |
| CAN interface | 8 | 4 per processor, CAN 2.0B, CANopen support, capable of system wake-up triggering |
| FlexRay interface | 4 | 2 per processor – all with integrated termination network, capable of system wake-up triggering |
| LIN interface | 2 | 1 per processor |
| RS232 driver | 2 | 1 per processor, full-duplex |
| Ethernet 100Base-TX | 2 | 1 per processor (TCP/IP) |
| rCube2 Morflink | 4 | 2 per processor (100 Mbit/s data exchange link to interconnect multiple rCube2 systems together) |

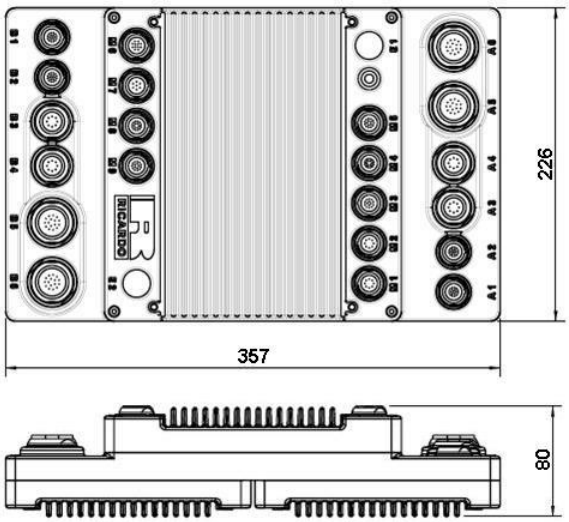
# Mechanical dimensions



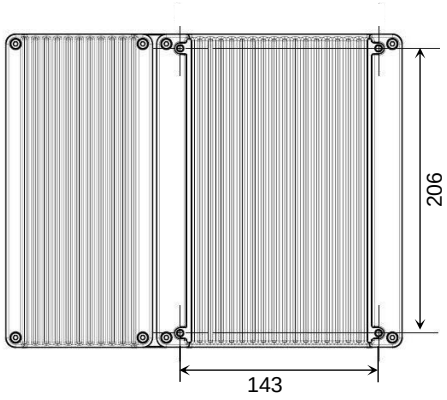

VARIANT I




VARIANT II




VARIANT III




Mounting hole locations VARIANT II/III base casting

All dimensions are in [mm]

# Mounting specification

Product mounting is by M4 screws. There are four threaded holes on the top surface of the MicroController Module (MCM is a common part of VARIANT I, II and III). Additionally, VARIANT II has four threaded holes on the bottom surface while VARIANT III has eight.

### System monitoring and power control

An integrated system monitor is responsible for waking-up the unit and managing system shutdown, it supports both CAN/FlexRay wake-up events and periodic wake-up events. The system monitor features internal temperature sensors with configurable overheat alarm warnings issued to the application processors and a hard-limit enforcing system shutdown.

## Environmental specifications

| Environmental parameter | Specification |
|---|---|
| Operating temperature | -40…+125 °C (can be limited by custom I/O modules) |
| Storage temperature limits | -40…+125 °C |
| Electrical transients | ISO7637 parts 1&2: 2002 |
| Vibration resistance | Designed according to EN16750-3 |
| Electro-static discharge | IEC 61000-4-2 |
| Water ingress<br>(with mating connectors installed) | IP68 |
| Weight (VARIANT I / II / III) | cca 2.5 / 5 / 8 kg |

## Tools and software environment specifications

| Item | Specification | Ricardo supplied |
|---|---|---|
| Operating system | Elektrobit AutoCore™ 2008a | ✓ |
| Processor peripheral drivers | Infineon MCAL drivers | ✓ |
| Application specific drivers | Ricardo developed | ✓ |
| Compiler | Tasking version 5.0 and 6.1 | × |
| System configuration | Elektrobit Tresos Studio™ ‘rCube2 Lite’ edition | ✓ |
| Calibration tools – XCP compliant | INCA 5.4.1 onwards | × |
| Calibration interface | Ethernet, CAN and ETAS ETK S4.2a (on request) | × |
| MATLAB®/Simulink®/<br>Simulink Coder™<br>Embedded Coder®<br>MATLAB Coder™ | 2013b, 2014b and 2015b<br>(Real-Time Workshop® in version 2013b) | ×<br>×<br>×<br>× |
| AUTOSAR Support from Embedded Coder® | (provided with Embedded Coder® in version 2013b) | × |

# Connector information

The rCube2 connector system is based on the rugged sealed Lemo™ 'K' series parts. See rCube2 connector information datasheet for further specifications and suitable cables.

| Ref # | Connector function | Lemo order code* |
|---|---|---|
| M1 | rCube2 Morflink comms | FGC.2K.316.CYCC70Z |
| M2 | PC host interfacing (Ethernet) and RS232 | FGC.2K.316.CYCC70Z |
| M3 | Analog inputs 9…18, thermistors 7…8 and 5 V sensor supply | FGG.2K.314.CYCC70Z |
| M4 | Analog inputs 1…8, thermistors 1…6 and 5 V sensor supply | FGA.2K.318.CYCC70Z |
| M5 | Processor 1 comms (CAN, FlexRay, LIN) and wake-up | FGG.2K.316.CYCC70Z |
| M6 | Relay drive outputs and Diagnostics LED outputs | FGG.2K.312.CYCC70Z |
| M7 | Main power and Low side drive outputs | FGG.2K.307.CYCC70Z |
| M8 | Digital inputs and outputs | FGA.2K.318.CYCC70Z |
| M9 | Processor 2 comms (CAN, FlexRay, LIN) and wake-up | FGG.2K.316.CYCC70Z |

*Note: The suffix (CYCxxxZ) determines the collet size for the cable and is dependent upon user application.

Full details of connectors and tooling are provided in the hardware user manual. These tools are not supplied by Ricardo.

# Contact Ricardo

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