PROtronic TopLINE

Article-No.: 1011448
Variant UCU-FS (Universal Control Unit for Functional Safety)

PROtronic TopLINE – The All-rounder for production-oriented Rapid Control Prototyping.
The innovative dual processor architecture in combination with flexibly configurable FPGA technology and powerful communication interfaces gives users a completely new range of freedom – and that is all in a compact and robust unit.

### Basic System

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Voltage</td>
<td>6.5 V ... 32 V DC</td>
</tr>
<tr>
<td>Temperature Range</td>
<td>-40 °C ... +75 °C case temperature</td>
</tr>
<tr>
<td>Electrical Strength</td>
<td>Short-circuit against Ground and V_{Bat} for all power supply terminals Power switches are also protected against overload</td>
</tr>
<tr>
<td>Mechanical Stress</td>
<td>Vibration and temperature testing according to DIN ISO 16750-3 Part 4.1.3.1.5.2, DIN EN 60068-2-64</td>
</tr>
<tr>
<td>IP code (EN 60529)</td>
<td>IP64K</td>
</tr>
<tr>
<td>EMV Stability</td>
<td>Interference emission/reception tests, CE conformal</td>
</tr>
<tr>
<td>External Connector</td>
<td>2 x 70-pin (AMP) 1 x 5-pin (ODU) 3 x 10-pin (ODU)</td>
</tr>
<tr>
<td>Housing</td>
<td>Aluminium, (W x H x L) 281 mm x 86 mm x 250 mm</td>
</tr>
<tr>
<td>Weight</td>
<td>Approx. 6 kg</td>
</tr>
</tbody>
</table>

### Dual-Processor Module

<table>
<thead>
<tr>
<th>Component</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Processor</td>
<td>NXP MPC8544 (@1 GHz)</td>
</tr>
<tr>
<td></td>
<td>▪ 256 KByte level 2 cache</td>
</tr>
<tr>
<td></td>
<td>▪ double precision Floating-Point-Unit</td>
</tr>
<tr>
<td>Memory</td>
<td>Flash: 64 MByte</td>
</tr>
<tr>
<td></td>
<td>RAM: 256 MByte</td>
</tr>
<tr>
<td></td>
<td>EEPROM: 32 KByte</td>
</tr>
<tr>
<td>Co-Processor</td>
<td>IBM PPC440 (@400 MHz)</td>
</tr>
<tr>
<td>Memory</td>
<td>Flash: 32 MByte</td>
</tr>
<tr>
<td></td>
<td>DDR2-RAM: 32 MByte</td>
</tr>
<tr>
<td></td>
<td>SRAM: 4 MByte</td>
</tr>
<tr>
<td></td>
<td>EEPROM: 256 kbit</td>
</tr>
<tr>
<td>FPGA</td>
<td>Virtex5 including 71,680 Logic Cells</td>
</tr>
<tr>
<td>Timer</td>
<td>Wake-up via user configurable timer</td>
</tr>
<tr>
<td>Watchdog</td>
<td>Watchdog for system monitoring</td>
</tr>
</tbody>
</table>

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## Communication Interfaces

**Measurement- & Calibration System:**
1 x 10/100 Mbit/s Ethernet, galvanically isolated up to 1500 Vrms, fully compliant to standard-Ethernet-Network

**Protocol:**
XCP on TCP/IP, XCP on UDP/IP

**IP-Address Distribution:**
Manually or via DHCP

**CAN:**
3 x CAN 2.0B Full-CAN (High-Speed, 1 MBaud max./ISO DIS 11898)
Alternative:
- 2 x ISO DIS 11898 and 1 x ISO DIS 11992 possible,
- 1 x CAN 2.0B Full-CAN (High-Speed, 1 MBaud max./ISO DIS 11898)
  wake-up capability

**FlexRay (available as an option):**
1 x FlexRay (2 channels) according to protocol specification 2.1,
- Freescale MFR4310 Communication Controller
- Software switchable termination
- Feed-through support to avoid stubs (if termination is not activated)

**LIN\(^2\):**
2 x LIN, according to LIN specification 1.3, 2.0, 2.1, 2.2
Configurable as LIN-Master or LIN-Slave

**Automotive Ethernet\(^3\):**
2 x BroadR-Reach® Ethernet

**SENT\(^6\):**
6 x SENT, according to SENT specification SAE J2716
Configurable in groups of 3 as SENT-Master or SENT-Slave

The following interfaces are supported by hardware, but currently not supported by software

**LVDS\(^1\):**
2 x 250 Mbit/s LVDS (low voltage differential signal) with dual ported memory

## Analog Inputs

**Number:**
24, 4 groups each with 6 channels
Standard hardware set-up:
- 6 x: U = 0 ... 10.14 V, fc = 14 kHz,
  typical application: load amplifier, pressure sensor
- 2 x: U = 0 ... 10.14 V, fc = 1.4 kHz,
  typical application: pressure sensor, active sensors
- 6 x: U = 0 ... 5.07 V, fc = 0.7 kHz,
  typical application: pressure sensor, active sensors
- 6 x: U = 0 ... 5.07 V, fc = 0.7 kHz,
  typical application: temperature sensor
- 4 x: U = 0 ... 5.07 V, fc = 0.7 kHz,
  typical application: potentiometer, positional sensor

**Resolution:**
12 Bit

**Input Voltage:**
Uni-polar or bi-polar (depending on hardware set-up)

**Input Filter (analog):**
Low-pass 1st order, cut-off frequency can be set via hardware set-up

**Input Filter (digital):**
Low-pass 1st order, cut-off frequency configurable

**Dynamic Behaviour:**
Sampling rate per channel: > 100 kHz

**Signal Types:**
- Analog input
- Digital input (with programmable threshold and hysteresis)

**Sensor Supply:**
Per group: 0 V ... VBat / 100 mA
### Analog Outputs, alternative\(^3\) to Analog Input Group 4

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>6, one group with 6 channels</td>
</tr>
<tr>
<td>Resolution</td>
<td>12 Bit</td>
</tr>
<tr>
<td>Output Voltage</td>
<td>0 ... 10 V/max. 10 mA</td>
</tr>
<tr>
<td>Dynamic Behaviour</td>
<td>Update rate: 70 kHz</td>
</tr>
</tbody>
</table>

### Crankshaft Inputs

<table>
<thead>
<tr>
<th>Parameter</th>
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</tr>
</thead>
</table>
| Number                     | 2 x hall sensor input: measurement range 0 ... 5.06 V, \(f_c = 66 \text{ kHz}\)  
2 x inductive sensor input: measurement range -29.9 ... + 29.9 V, \(f_c = 16 \text{ kHz}\)  
Common sensor voltage  
Further inputs for processing of crank circuit signals available for fast digital inputs / outputs. |
| Operating Range            | Engine speed 50 ... 12000 \text{ rpm}\(^4\)        |
| Crankshaft Tooth System    | Configurable, 36 – 3600 teeth with 1 to 4 gaps or one additional tooth, e.g. 36±1, 60-(1...4), 60-1-1 (symmetrically), 360 increments / revs, 3600 increments / revs, etc. |
| Camshaft Tooth System      | Configurable, 1 to 15 teeth                         |
| Resolution                 | 0.1 °KW                                              |
| Sensor Type                | Inductive or hall                                   |
| Dynamic Behavior           | Sampling rate per channel: 500 kHz                  |
| Sensor Supply              | 0 V ... V\(_{\text{Bat}}\)/100 mA                   |

### Fast Digital Inputs / Outputs

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>12, 2 groups each with 6 channels, in groups as input / output configurable</td>
</tr>
</tbody>
</table>
| Input                      | 5 ... 32 V, threshold configurable group-wise  
Standard equipment: 24.8 kΩ, pull-down |
| Output                     | Push/pull output 75 Ω                              |
| Input signal types         | - Digital input  
- Pulse and frequency measurement input  
- Event generation at edge change input |
| Output signal types        | - Digital output  
- PWM output |
### Power Switch Outputs

| Number: | 24, 4 groups with 6 channels each |
| Supply: | Per group, 6.5 ... 52 V external |
| Output: | Push/pull, low side or high side output 5 A, 11 A peak Parallel switching of up to 6 channels possible Load capacity of supply: max. 20 A per group |
| Signal Types: | - Digital output  
- PWM output, 20 Hz ... 10 kHz  
- Full bridge output, 20 Hz ... 10 kHz  
- Peak & Hold output, 20 Hz ... 10 kHz  
- Peak & Hold current measurement  
- Pulse output (angle-synchronous)  
- Ignition output (control of external power stages), max. 20 ms  
- Current controlled output |

### Ignition Outputs

| Number: | 6, one group with 6 channels for control of an external ignition power stage Diagnosis functions of external ignition power stage |
| Output: | 0 ... 4.6 V, push/pull voltage output or 8 ... 25 mA power output, max. 16 V |
| Signal Types: | Ignition Control |

1. Only supported by hardware, currently not supported by software.  
2. Additional software required (LIN ACI-Blockset).  
3. Not included in standard version.  
4. For incremental sensors, a lower maximum rev. speed applies depending on the number of teeth.  
5. Can be used only as Bypass-Master interface. Additional software required (Bypass ACI-Blockset).  
6. While using the SENT interface the fast digital I/O groups will be reduced by one.
**Functional Safety Concept of PROtroniC TopLINE UCU-FS**

The functional safety concept of the PROtroniC TopLINE UCU-FS consists of two main parts:

1. A multilevel monitoring concept for developing application-specific safety functions in the PROtroniC control unit.

**Overview Safety Concept:**

- Main CPU runtime monitoring with independent safety processor
- Freely programmable monitoring level (level 2) to verify correct execution of main software
- Enforcement of defined state of inputs and outputs on detected faults
- Configurable shut-down trigger option from desired software level, to ensure a safe state of system on detected faults
- Monitoring of functional code execution
- Monitoring of runtime response and instruction code test
- Monitoring and diagnostics of system integrity and supply voltages
- Extensive diagnostics functions of the inputs and outputs
- Initial and cyclic check of system memory (RAM, code and data segments)
- System-watchdog
- Integrated fault detection and fault memory functionality
- Max. number of re-start trials configurable by user
- Option to switch off the safety functions for development and test purpose
Development Environment

Smooth transition from design to mass production
The development environment of the PROtronic TopLINE is based on tools that are widespread in the automotive industry. It not only offers free scope when choosing the code generator but also for measurement and calibration tools.

1 Model-based software development
- Graphical modeling of control functions with MATLAB®, Simulink® and Stateflow®.

2 Offline simulation
- Testing and optimisation of the functional design against a plant design using offline simulation on the PC with MATLAB®, Simulink® and Stateflow®.

3 Hardware mapping
- Mapping and configuration of the control functions in the model to the inputs and outputs of the hardware using a graphic block library based on Simulink® – Application Controller Interface (ACI).

4 Automatic code generation
- Generation of highly efficient production code at the press of a button, alternatively with the code generators TargetLink® or Embedded Coder™.

5 Test and verification
- Downloading the generated software to the control unit with Schaeffler Engineering boot loader tool.
- Testing and verification of the new developed control functions on a test-stand, in the vehicle or via hardware-in-the-loop simulation.

6 Measurement and calibration
- Fine tuning and measurement of the control functions using a measurement and calibration tool, alternatively with MARC I, INCA or CANape.