Introduction

PL360G55CB-EK is an evaluation kit for the PL360 modem. PL360 is a programmable modem for narrow-band Power Line Communication (PLC) from Microchip Technology Inc, able to run any PLC protocol in the frequency band below 500 kHz. The PL360 has been conceived to be driven by external Microchip host controller devices; in this case a SAMG55 ARM® Cortex®-M4 RISC processor is used. The Microchip host device loads the corresponding PLC-protocol firmware and then controls the PL360 modem operation.

The PL360G55CB-EK board has been conceived to communicate in CENELEC B-Band (95 kHz to 125 kHz) and it complies with CENELEC standard EN 50065 regulations and Smart Energy applications. It can be connected directly to AC mains or DC power rails.

Contents

- Welcome letter
- Board:
  - One PL360G55CB-EKv2 board
- Cable:
  - One Micro A/B-type USB cable
- Jumpers:
  - Two jumpers with pitch 1.27 mm
- Pin Headers:
  - Two 8-pin headers with pitch 2.54 mm

Features

- PL360G55CB-EK board mounts a PL360 PLC transceiver and a SAMG55J19 ARM Cortex M4 microcontroller.
- PL360G55CB-EK board provides a full featured platform to develop a complete communications system based on PLC technology working in CENELEC B-Band.
- PL360 is a compact and highly efficient device for a wide range of Smart Grid applications such as lighting control, industrial/home automation and renewable-energy management, among others.
- PL360G55CB-EK board provides support for:
  - PLC band characterization and noise level measurement
  - PLC sensitivity level measurement
  - Power consumption
  - Power fail detection
- PL360G55CB-EK board includes a SWD/JTAG interface for MCU debugging and programming purposes. Firmware is also upgradable via USB/serial interface
- USB 2.0 full-speed interface
• **mikroBUS™** add-on connectors to integrate the board itself as a module for interfacing with other microcontrollers or microprocessors (mikroBUS main board).

• PL360G55CB-EK board can be externally supplied by:
  - mikroBUS connector
  - Micro-B USB connector
  - DC Jack connector
# Table of Contents

Introduction ......................................................................................................................1

Contents .......................................................................................................................... 1

Features .......................................................................................................................... 1

1. Evaluation Kit Specifications ..................................................................................... 4
   1.1. Safety Recommendations .......................................................................................... 4
   1.2. Electrical Specifications ........................................................................................... 4

2. Getting Started .......................................................................................................... 6
   2.1. Powering-Up the Board .......................................................................................... 6
   2.2. Running Preloaded Firmware ............................................................................... 7
   2.3. Code and Technical Support ................................................................................... 7

3. PL360G55CB-EK Board ............................................................................................ 9
   3.1. Overview ................................................................................................................ 9
   3.2. Features List .......................................................................................................... 9
   3.3. Hardware Description – System .......................................................................... 16
   3.4. Hardware Description – MCU Peripherals .......................................................... 26
   3.5. Hardware Description – MCU Interface Ports .................................................... 28
   3.6. PL360G55CB-EK Schematics .............................................................................. 30
   3.7. PL360G55CB-EK Layout ...................................................................................... 34

4. Compliance for Specific Standards ........................................................................... 40

5. References .............................................................................................................. 41

6. Revision History ....................................................................................................... 42
   6.1. Rev A - 04/2019 .................................................................................................... 42

The Microchip Web Site ................................................................................................ 43

Customer Change Notification Service ........................................................................ 43

Customer Support ......................................................................................................... 43

Microchip Devices Code Protection Feature ............................................................... 43

Legal Notice ................................................................................................................... 44

Trademarks ................................................................................................................... 44

Quality Management System Certified by DNV ............................................................. 45

Worldwide Sales and Service ....................................................................................... 46
1. **Evaluation Kit Specifications**

1.1 **Safety Recommendations**

This evaluation board must only be used by expert technicians. The PL360G55CB-EK board is powered from a DC power source, so only the PLC coupling stage could have a hazardous voltage when is connected to mains. The risk of electric shock is minimized since all required connectors and configuration jumpers are galvanically isolated from the coupling stage.

![CAUTION]

Be careful, there is risk of electric shock in the PLC coupling stage. A normal use of the PL360G55CB-EK board is for indoor use only.

This evaluation board does not have any switch on mains connection to switch it on or off.

To avoid damage of measurement instruments, do not connect any probe to the high voltage sections if the board is not isolated from the mains supply.

Temperature operating range should be from 0°C to +85°C. Running extended periods at minimum and maximum values may cause permanent damage to the board. Quartz crystal components could not cover previous temperature range with desired performance due to aging.

The evaluation board is intended for further engineering, development, demonstration, or evaluation purposes only. It is not a finished product, unless otherwise noted on the board/kit.

![ Important: ]

Microchip does not assume any responsibility for the consequences arising from any improper use of this board.

1.2 **Electrical Specifications**

This section shows the electrical characteristics of the PL360G55CB-EK board.

**Table 1-1. Power Supply Requirements**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Condition</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC Mains Voltage Range</td>
<td>DC Jack Connector, J8</td>
<td>6</td>
<td>-</td>
<td>30</td>
<td>V&lt;sub&gt;DC&lt;/sub&gt;</td>
</tr>
<tr>
<td>Maximum Input Current</td>
<td>DC Jack Connector, J8</td>
<td></td>
<td>590&lt;sup&gt;1&lt;/sup&gt;</td>
<td>mA</td>
<td></td>
</tr>
<tr>
<td>Isolation Voltage</td>
<td>PLC coupling transformer</td>
<td></td>
<td>3000</td>
<td>V&lt;sub&gt;AC&lt;/sub&gt;</td>
<td></td>
</tr>
</tbody>
</table>

Note that the PL360G55CB-EK can be supplied with several power sources. For more information about the power supply system, see section 3.3.6 Power Supply System.

**Note:**

1. Board supplied with 6 V<sub>DC</sub>, transmission against very low impedance (2Ω) and all peripherals are on.
Table 1-2. Power Consumption

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Condition</th>
<th>Consumption</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>TX Power Consumption</td>
<td>FW: G3 CEN-B PHY TX Test Console Application.</td>
<td>1932(^1)</td>
<td>mW</td>
</tr>
<tr>
<td></td>
<td>Low Impedance Load (2Ω LISN, see Figure C.1 of ITU-T G.9901).</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Measured on 12V DC/DC output.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>FW: G3 CEN-B PHY TX Test Console Application.</td>
<td>322(^1)</td>
<td>mW</td>
</tr>
<tr>
<td></td>
<td>High Impedance Load (CISPR LISN, see Figure 5 of EN 50065-1).</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Measured on 12V DC/DC output.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RX Power Consumption</td>
<td>Measured on 3.3V DC/DC output</td>
<td>264(^1)</td>
<td>mW</td>
</tr>
</tbody>
</table>

Notes:

1. These measurements were taken running the PHY TX Test Console project with a default configuration in TX and RX modes, and correspond to the whole PCBA design and not only to PL360 and SAMG55J19 devices. All PCB is supplied in the worst consumption conditions (board is supplied with a minimum input voltage, 6 V\(_{\text{DC}}\)) and emitting in CENELEC B-band. Refer to PL360 and SAMG55 datasheets for their respective power consumption.
2. Getting Started

2.1 Powering-Up the Board

Unpack and inspect the kit carefully.

Figure 2-1. Unpacked PL360G55CB-EK

Kit contents are covered by anti-static foam. The PL360G55CB-EK board is shipped in an anti-static shielding bag.

WARNING The board must not be subject to high electrostatic discharge. We recommend using a grounding strap or similar ESD protective device when handling the board in hostile ESD environments. Avoid touching the components’ pins or any other metallic elements on the board.
Take into account that the connectors to supply the board are different than the one for PLC signals. The board can be supplied by three different ways:

- +5V from USB Micro-B connector (J4)
- +5V from mikroBUS connector (J6)
- DC voltage (from +6V to +30V) from DC Jack connector (J8)

### 2.2 Running Preloaded Firmware

Once the board is supplied, LEDs will show activity. The PL360G55CB-EK board is delivered with a pre-programmed application in SAMG55 Flash memory: the G3-PLC PHY Tester for CENELEC B-Band. PLC communications are developed for CENELEC B-Band in AC or DC voltage grid.

The kit includes a USB 2.0 type A to Micro-B cable that can be used to connect the board to a computer. Connect a suitable cable in the PLC connector (J1) and plug it to an AC/DC voltage grid to communicate.

By means of the PLC PHY Tester PC application, it is possible to send and receive PLC messages using the PHY layer in the CENELEC B-Band according to the binary flashed in PL360G55CB-EK board.

### 2.3 Code and Technical Support

Firmware developers can not only run the given example code, but also implement their own applications based on the provided firmware stacks.
Please note that the latest software code, documentation and support materials are available online. Follow instructions described in the welcome letter for more information.

For any technical support requests, please visit http://support.microchip.com.
3. **PL360G55CB-EK Board**

3.1 **Overview**

This section summarizes the PL360G55CB-EK board design. It introduces system-level concepts, such as power supply, MCU, PLC coupling, peripherals and interface board.

PL360G55CB-EK is a PLC modem board based on the PL360 transceiver and on the SAMG55 ARM Cortex-M4 RISC processor. This evaluation board can be used as a PLC modem reference design for modular architectures; or, in any case to provide a platform to develop a complete communications system over PLC technology.

**Figure 3-1. PL360G55CB-EKv2 Board Description**

3.2 **Features List**

The PL360G55CB-EK board includes the following features:

- PL360 PLC Transceiver:
  - Multi-protocol PLC modem:
    - G3-PLC
    - PRIME 1.3 and PRIME 1.4
- One SPI peripheral to external MCU
- Zero-Cross Detection
- Embedded PLC Analog Front End (AFE)
- Low-power consumption in transmission and reception

- **SAMG55 MCU:**
  - **Core:**
    - ARM Cortex-M4 running at up to 120 MHz
    - Memory Protection Unit (MPU)
    - DSP instruction set
    - Floating-Point Unit (FPU)
    - Thumb \textsuperscript{2} instruction set
    - Instruction and Data Cache Controller with 2 Kbytes cache memory
    - Up to 512 Kbytes of embedded Flash, 176 Kbytes of embedded SRAM, 8 Kbytes of ROM
  - **Memories:**
    - Up to 512 Kbytes of embedded Flash
    - Up to 176 Kbytes of embedded SRAM
    - Up to 8 Kbytes of ROM with embedded bootloader, single-cycle access at full speed

- **PLC Coupling** designed to communicate in CENELEC B-Band (95 kHz to 125 kHz)
- A 3.3V buck converter for the digital circuitry and a 12V Buck-Boost converter for supplying the PLC Power Amplifier. It allows supply of the board with any of the three different power sources
- **Mains Zero-Crossing Detector Circuit**
- **Peripherals:***
  - Supply monitor
  - User LEDs
  - Reset button
  - Chip Erase jumper
  - Chip Programming jumper
- **Interfaces:**
  - USB Device
  - mikroBUS add-on connectors
  - SWD/JTAG debugging port

### 3.2.1 PL360G55CB-EK Block Diagram

The following figure shows the block diagram of the PL360G55CB-EK board.
3.2.2 Interface Connection

The PL360G55CB-EK board includes hardware interfaces such as jumpers, connectors and a button. Following figure shows an overview of the connectors, jumpers and button of the PL360G55CB-EK board.
3.2.2.1 Connectors

The PL360G55CB-EK board includes the following connectors:

1. PLC connector (for an AC/DC grid), J1.

```
PLC Connector (J1)
Test Point PLC signal (TP107)
ERASE Pin Header (J3)
USB Device Connector (J4)
DC Input Connector (J8)
Test Point 3V3 Voltage (TP10)
Test Point 12V Voltage (TP6)
Test Point GND Voltage (TP16)
mikroBUS Connectors (J5 & J6)
RESET Button (SW1)
JTAG/SWD Connector (J7)
PROG Pin Header (J2)
```
### Table 3-1. PLC Connector (for an AC/DC grid), J1

<table>
<thead>
<tr>
<th>Pin</th>
<th>Signal Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>L / +VDC</td>
<td>Line / Positive Voltage</td>
</tr>
<tr>
<td>2</td>
<td>N / -VDC</td>
<td>Neutral / Negative Voltage</td>
</tr>
</tbody>
</table>


### Table 3-2. USB Device Connector, J4

<table>
<thead>
<tr>
<th>Pin</th>
<th>Signal Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>VUSB</td>
<td>5V power</td>
</tr>
<tr>
<td>2</td>
<td>D+</td>
<td>Data Plus</td>
</tr>
<tr>
<td>3</td>
<td>D-</td>
<td>Data Minus</td>
</tr>
<tr>
<td>4</td>
<td>ID</td>
<td>On the Go Identification</td>
</tr>
<tr>
<td>5</td>
<td>GND</td>
<td>Ground</td>
</tr>
</tbody>
</table>

3. mikroBUS add-on connectors, J5 and J6.

### Table 3-3. mikroBUS Connector, J5

<table>
<thead>
<tr>
<th>Pin</th>
<th>Mnemonic</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AN</td>
<td>Analog</td>
</tr>
<tr>
<td>2</td>
<td>RST</td>
<td>Reset</td>
</tr>
<tr>
<td>3</td>
<td>CS</td>
<td>SPI Chip Select</td>
</tr>
<tr>
<td>4</td>
<td>SCK</td>
<td>SPI Clock</td>
</tr>
<tr>
<td>5</td>
<td>SDO</td>
<td>SPI Master Input Slave Output</td>
</tr>
<tr>
<td>6</td>
<td>SDI</td>
<td>SPI Master Output Slave Input</td>
</tr>
<tr>
<td>7</td>
<td>3V3</td>
<td>VCC - 3.3V power</td>
</tr>
<tr>
<td>8</td>
<td>GND</td>
<td>Reference Ground</td>
</tr>
</tbody>
</table>

### Table 3-4. mikroBUS Connector, J6

<table>
<thead>
<tr>
<th>Pin</th>
<th>Mnemonic</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PWM</td>
<td>PWM</td>
</tr>
<tr>
<td>2</td>
<td>INT</td>
<td>Hardware Interrupt</td>
</tr>
<tr>
<td>3</td>
<td>TX</td>
<td>UART Transmit</td>
</tr>
<tr>
<td>4</td>
<td>RX</td>
<td>UART Receive</td>
</tr>
<tr>
<td>5</td>
<td>SCL</td>
<td>I²C Clock</td>
</tr>
<tr>
<td>6</td>
<td>SDA</td>
<td>I²C Data</td>
</tr>
<tr>
<td>7</td>
<td>5V</td>
<td>VCC - 5V power</td>
</tr>
</tbody>
</table>
4. JTAG/SWD 10-pin connector for SAMG55J19, J7.

**Table 3-5. SW-DP Connector, J7**

<table>
<thead>
<tr>
<th>Pin</th>
<th>Mnemonic</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>VCC</td>
<td>This is the target reference voltage. It is used to check if the target has power, to create the logic-level reference for the input comparators, and to control the output logic levels to the target. It is normally fed from VCC on the target board and must not have a series resistor.</td>
</tr>
<tr>
<td>2</td>
<td>SWDIO/TMS</td>
<td>Serial Wire Input Output / Test Mode Select. JTAG mode set input of target CPU. This pin should be pulled up on the target. Output signal that sequences the target's JTAG state machine, sampled on the rising edge of the TCK signal.</td>
</tr>
<tr>
<td>3</td>
<td>GND</td>
<td>Ground.</td>
</tr>
<tr>
<td>4</td>
<td>SWDCLK/TCK</td>
<td>Serial Wire Clock / Test Clock. JTAG clock signal to target CPU (output timing signal, for synchronizing test logic and control register access).</td>
</tr>
<tr>
<td>5</td>
<td>GND</td>
<td>Ground.</td>
</tr>
<tr>
<td>6</td>
<td>SWO/TDO</td>
<td>Test Asynchronous Data Out from target CPU.</td>
</tr>
<tr>
<td>7</td>
<td>KEY</td>
<td>-</td>
</tr>
<tr>
<td>8</td>
<td>NC/TDI</td>
<td>Not Connected / Test Data Input. JTAG data input of target CPU (serial data output line, sampled on the rising edge of the TCK signal). It is recommended that this pin is pulled to a defined state on the target board.</td>
</tr>
<tr>
<td>9</td>
<td>GND Detect</td>
<td>Ground.</td>
</tr>
<tr>
<td>10</td>
<td>nRESET</td>
<td>JTAG Reset (active-low output signal that resets the target). Output from SAM-ICE™ to the Reset signal on the target JTAG port. This pin is normally pulled HIGH on the target to avoid unintentional resets when there is no connection.</td>
</tr>
</tbody>
</table>

5. DC Input connector, J8.

**Table 3-6. DC Input Connector, J8**

<table>
<thead>
<tr>
<th>Pin</th>
<th>Signal Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DC_IN</td>
<td>DC Input voltage (6 - 30V)</td>
</tr>
<tr>
<td>2</td>
<td>GND</td>
<td>Ground</td>
</tr>
<tr>
<td>3</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
### 3.2.2.2 Jumper Configurations

The following table describes the functionality of the jumpers.

**Table 3-7. Jumper Configuration**

<table>
<thead>
<tr>
<th>Jumper</th>
<th>Label</th>
<th>Default Setting</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>J3</td>
<td>ERASE</td>
<td>Open</td>
<td>SAMG55J19 Flash memory code erase (closed = erase).</td>
</tr>
<tr>
<td>J2</td>
<td>PROG</td>
<td>Open</td>
<td>SAMG55J19 Flash memory upgrade (closed = programming).</td>
</tr>
</tbody>
</table>

**Note:** Pitch jumpers are 1.27 mm (0.050").

### 3.2.2.3 Test Points

Some test points (probes and pads) have been placed on the PL360G55CB-EK board for the verification of the main signals.

**Table 3-8. Test Point Probes**

<table>
<thead>
<tr>
<th>Reference</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP6</td>
<td>12V</td>
</tr>
<tr>
<td>TP10</td>
<td>3V3</td>
</tr>
<tr>
<td>TP16</td>
<td>GND</td>
</tr>
<tr>
<td>TP107</td>
<td>PLC signal</td>
</tr>
</tbody>
</table>

**Table 3-9. Test Point Pads**

<table>
<thead>
<tr>
<th>Reference</th>
<th>Function</th>
<th>Reference</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP1</td>
<td>PROG</td>
<td>TP24</td>
<td>PL360 pin PA7</td>
</tr>
<tr>
<td>TP2</td>
<td>ERASE</td>
<td>TP25</td>
<td>PL360 pin PA8</td>
</tr>
<tr>
<td>TP3</td>
<td>SAMG55J19 pin PA12, LED D1</td>
<td>TP26</td>
<td>PL360 pin PA9</td>
</tr>
<tr>
<td>TP4</td>
<td>SAMG55J19 pin PA15, LED D2</td>
<td>TP27</td>
<td>PL360 pin PA0</td>
</tr>
<tr>
<td>TP5</td>
<td>NRST</td>
<td>TP28</td>
<td>PL360 pin PA3</td>
</tr>
<tr>
<td>TP7</td>
<td>12V</td>
<td>TP100</td>
<td>PL360 pin TXRX1</td>
</tr>
<tr>
<td>TP8</td>
<td>DC_IN</td>
<td>TP101</td>
<td>P Channel MOSFET</td>
</tr>
<tr>
<td>TP9</td>
<td>VDC</td>
<td>TP102</td>
<td>Line</td>
</tr>
<tr>
<td>TP11</td>
<td>3V3</td>
<td>TP103</td>
<td>N Channel MOSFET</td>
</tr>
<tr>
<td>TP12</td>
<td>Ground</td>
<td>TP104</td>
<td>Neutral</td>
</tr>
<tr>
<td>TP13</td>
<td>Ground</td>
<td>TP105</td>
<td>Zero cross signal, VZC</td>
</tr>
<tr>
<td>TP14</td>
<td>Ground</td>
<td>TP106</td>
<td>PL360 pin TXRX0</td>
</tr>
<tr>
<td>TP15</td>
<td>Ground</td>
<td>TP108</td>
<td>PLC RX</td>
</tr>
<tr>
<td>TP23</td>
<td>PL360 pin PA6</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
3.3 Hardware Description – System

3.3.1 PL360

The PL360G55CB-EK board is equipped with a PL360 device in 48-pin QFN (0.4 mm pitch).

PL360 is a multi-protocol (G3-PLC, PRIME 1.3 and PRIME 1.4) modem for Power Line Communication implementing a very flexible architecture, which allows implementation of standard and customized PLC solutions.

PL360 transceiver has been conceived to be easily managed by an external Microchip MCU through a 4-line standard Serial Peripheral Interface (SPI) accessing the internal peripheral registers. Two additional signals are used by the host microcontroller to control the PL360 transceiver: LDO enable and NRST.

Figure 3-4. PL360 PLC Modem

---

**Important:** Some GPIOs of PL360 device must be connected to the external MCU for the right implementation of the firmware of the PLC standard. G3-PLC requires a GPIO for an external interrupt line (EINT) and PRIME requires two GPIOs for an external interrupt and carrier detect indication lines (EINT and CD). Please, check this point with the firmware user guide.

**Remember:** The PL360 control lines from MCU perspective (SPI lines, EINT in GPIO3 and CD in GPIO0) are accessible via test points.

Microchip provides highly efficient, reduced BOM reference designs for different coupling options, targeting common configurations in all PLC bands (<500 kHz) complying with existing regulations.
For a further description of the PL360 device see the corresponding PL360 datasheet.

### 3.3.2 SAMG55J19

The PL360G55CB-EK board is equipped with a SAMG55J19 device in 64-pin QFN. The SAM G55 devices are general-purpose low-power microcontrollers which offer high performance, processing power and small package options combined with a rich and flexible peripheral set.

The Microchip’s SAM G55 embeds a Cortex-M4 CPU with an FPU (floating point unit). This ensures maximum throughput. This is very important as it allows minimization of the active power consumption and getting to sleep faster in order to reduce the overall power consumption. Additionally, the device has 30 DMA channels, which gives extremely high throughput.

The SAMG55J19 operates at a maximum speed of 120 MHz and features 512 Kbytes of Flash and up to 176 Kbytes of SRAM. The peripheral set includes eight flexible communication units comprising of USARTs, SPIs and I²C-bus interfaces (TWIs), two three-channel general-purpose 16-bit timers, two I²S controllers, one-channel pulse density modulation, one 8-channel 12-bit ADC, one Real-Time Timer (RTT) and one Real-Time Clock (RTC), both located in the ultra-low power backup area.
Table 3-10 and Table 3-11 summarize the functionality of each input/output line of the SAMG55J19 microcontroller in PL360G55CB-EK board.

Table 3-10. Pinout of SAMG55J19 PortA in PL360G55CB-EK Board

<table>
<thead>
<tr>
<th>I/O LINE</th>
<th>Function</th>
<th>I/O LINE</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>PA0</td>
<td>PL360 GPIO3</td>
<td>PA16</td>
<td>PL360 GPIO4</td>
</tr>
<tr>
<td>PA1</td>
<td>PL360 GPIO2</td>
<td>PA17</td>
<td>AD0 (mikroBUS)</td>
</tr>
<tr>
<td>PA2</td>
<td>Not Connected</td>
<td>PA18</td>
<td>PROG</td>
</tr>
<tr>
<td>PA3</td>
<td>PL360 MOSI</td>
<td>PA19</td>
<td>Voltage Monitor</td>
</tr>
<tr>
<td>PA4</td>
<td>PL360 MISO</td>
<td>PA20</td>
<td>Not Connected</td>
</tr>
<tr>
<td>PA5</td>
<td>PL360 GPIO1</td>
<td>PA21</td>
<td>USB Device Diff Negative</td>
</tr>
<tr>
<td>PA6</td>
<td>PL360 GPIO5</td>
<td>PA22</td>
<td>USB Device Diff Positive</td>
</tr>
<tr>
<td>PA7</td>
<td>XIN32</td>
<td>PA23</td>
<td>TIOA1 (mikroBUS)</td>
</tr>
<tr>
<td>PA8</td>
<td>XOUT32</td>
<td>PA24</td>
<td>Not Connected</td>
</tr>
<tr>
<td>PA9</td>
<td>SPI0 MISO (mikroBUS)</td>
<td>PA25</td>
<td>SPI0 CS0 (mikroBUS)</td>
</tr>
<tr>
<td>PA10</td>
<td>SPI0 MOSI (mikroBUS)</td>
<td>PA26</td>
<td>Not Connected</td>
</tr>
<tr>
<td>PA11</td>
<td>USB Detect</td>
<td>PA27</td>
<td>Not Connected</td>
</tr>
<tr>
<td>PA12</td>
<td>User LED0</td>
<td>PA28</td>
<td>Not Connected</td>
</tr>
<tr>
<td>PA13</td>
<td>Not Connected</td>
<td>PA29</td>
<td>PL360 NRST</td>
</tr>
<tr>
<td>PA14</td>
<td>WKUP8 (mikroBUS)</td>
<td>PA30</td>
<td>PL360 LDO_EN</td>
</tr>
</tbody>
</table>
The right implementation of the PLC standards require some GPIOs of the transceiver PL360 connected to the SAMG55. G3-PLC requires a GPIO for an external interrupt line (PA0 of SAMG55) and PRIME requires two GPIOs for an external interrupt and carrier detect (PA0 and PA31 of SAMG55) indication lines. Please check this point with the firmware user guide.

For a further description of the SAMG55J19 capabilities see the corresponding SAMG55 datasheet.

### 3.3.3 Clock Circuitry

Besides the embedded RC oscillators of SAMG55J19, two crystal oscillators are assembled on the PL360G55CB-EK board to obtain a more precise and stable system clock reference:

- A 24 MHz clock signal, Y1, generated for the PLC transceiver PL360
- A low-power 32.768 kHz crystal oscillator, Y2, for the SAMG55J19

#### Figure 3-7. 24 MHz Crystal Oscillator Scheme
3.3.4 Reset

The reset sources of the PL360G55CB-EK board are:

- Power-on Reset function, embedded in the SAMG55 device.
- Push button reset. Both devices, SAMG55J19 and PL360, have a NRST pin: “NRST” for SAMG55J19 and “NRST_360” for PL360. The user can manually reset the SAMG55J19, which manages the PL360 reset, by using the push button SW1. See section 3.4.2.2 Push Buttons.
- JTAG reset from an in-circuit emulator.

3.3.5 PLC Coupling Circuitry Description

The European regulations concerning Power Line Communications are described in CENELEC standard EN 50065. This standard applies to electrical equipment using signals in the frequency range 3 kHz to 148.5 kHz to transmit information on low voltage electrical systems, either on the public supply system or within installations in consumers’ premises. The following figure shows the different frequency bands allocated to the different applications.
The PL360G55CB-EK evaluation board communicates in the CENELEC B-Band frequency. The use of frequencies in this band shall be restricted to consumer use; for example, for end-user applications such as industrial applications.

Microchip has designed five coupling reference designs for CENELEC B-Band with variations in the BOM cost and the communication performance. Table 3-12 summarizes the main features of the available designs.

Table 3-12. Characteristics of PLCOUPxxx Boards for CENELEC B-Band

<table>
<thead>
<tr>
<th>Board Name</th>
<th>Description</th>
<th>Frequency Band (kHz)</th>
<th>Branch</th>
<th>Electrical Isolation</th>
<th>PRIME Channel</th>
<th>G3-PLC Band</th>
<th>Applicable Regulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLCOUP012-ISO</td>
<td>Low cost with internal driver G3 CENELEC B compliant</td>
<td>95 - 125</td>
<td>Single</td>
<td>Yes</td>
<td>-</td>
<td>G3</td>
<td>CENELEC EN 50065</td>
</tr>
<tr>
<td>PLCOUP012-NONISO</td>
<td>Low cost with internal driver G3 CENELEC B compliant</td>
<td>95 - 125</td>
<td>Single</td>
<td>No</td>
<td>-</td>
<td>G3</td>
<td>CENELEC EN 50065</td>
</tr>
<tr>
<td>PLCOUP013</td>
<td>Ultra low cost with internal driver and non-Isolated G3 CENELEC B compliant</td>
<td>95 - 125</td>
<td>Single</td>
<td>No</td>
<td>-</td>
<td>G3</td>
<td>CENELEC EN 50065</td>
</tr>
<tr>
<td>PLCOUP014-ISO</td>
<td>G3 CENELEC B compliant</td>
<td>95 - 125</td>
<td>Single</td>
<td>Yes</td>
<td>-</td>
<td>G3</td>
<td>CENELEC EN 50065</td>
</tr>
<tr>
<td>PLCOUP014-NONISO</td>
<td>G3 CENELEC B compliant</td>
<td>95 - 125</td>
<td>Single</td>
<td>No</td>
<td>-</td>
<td>G3</td>
<td>CENELEC EN 50065</td>
</tr>
</tbody>
</table>

The PL360G55CB-EK board is assembled with the PLCOUP014-ISO coupling design. The goal is to provide a cost-optimized fully-featured design according to the G3-PLC requirements. Still, the PL360G55CB-EK board is designed to allow using all the other coupling designs by changing the corresponding components and firmware configurations.

**Important:** Check the online resources from Microchip website to download the proper files according to your desired CENELEC B-Band design.
The following figure shows the PLC Coupling assembled (PLCOUP014-ISO) which is composed of four sub-circuits:

1. Transmission Stage
2. Filtering Stage
3. Coupling Stage
4. Reception Stage

Figure 3-10. PLC Coupling Schematic on PL360G55CB-EK Board

Remember: PLC Coupling circuitry adds a yellow LED, D104, for visual indication of PLC frames transmission.

The following sections describe the aim of every sub-circuit assembled in the PL360G55CB-EK board.

3.3.5.1 PLC Transmission Circuit
The transmission stage adapts the EMIT signals and amplifies them. In the PL360G55CB-EK board, see Figure 3-10, it is a single branch composed of:

- Driver: It adapts the EMIT signals to either control the amplifier or to be filtered by the next stage
- Amplifier: A Class-D amplifier generating a square waveform from 0 to 12V
- Bias and protection: It provides a DC component and provides protection from received disturbances

The transmission stage is followed by a filtering stage.

3.3.5.2 PLC Filtering Circuit
The in-band flat response filtering stage reduces spurious emission to the limits set by the corresponding regulation and blocks potential interferences from other transmission channels without distorting the injected signal.

The filtering stage used in PL360G55CB-EK, see Figure 3-10, has three aims:

- Band-pass filtering of high frequency components of the square waveform generated by the transmission stage
• Adapt Input/Output impedance for optimal reception/transmission. This is controlled by TXRX0 signal
• A band-pass filtering for received signals

### 3.3.5.3 PLC Coupling Circuit

PLC coupling circuit connects the PLC signal directly to the mains grid or even to DC power rails without requiring any hardware adaptation. The main purpose of the circuit is to block the mains voltage of the grid to/from which the signal is injected/received. This is carried out in PL360G55CB-EK, see Figure 3-10, by a high voltage capacitor, C103. Resistors R108, R112 and R115 allow the high voltage capacitor to discharge after disconnection from mains.

⚠️ **CAUTION**

PLC coupling components are designed for a maximum voltage of 230 \( V_{AC} \) or 200 \( V_{DC} \).

The TR100 transformer (with turn ratio 1:1) provides galvanic isolation from mains. A non-isolated version could easily be implemented removing TR100, soldering R106 and R116 resistors and updating the value of L103 according to the PLCOUP014-NONISO design.

MOV100 varistor, F100 fuse and D102 TVS diode protect the coupling circuit from the overvoltages and high transient voltages (surges and spikes) from mains.

### 3.3.5.4 PLC Reception Circuit

The PLC reception circuit used in PL360G55CB-EK, see Figure 3-10, is the reference design for the reception stage and it is composed of:

• Single-pole low pass filter, R133 and C109
• Automatic Gain Control (AGC) circuit. A resistor, R134, is used to attenuate the incoming PLC signal in case its amplitude is high enough to exceed the input dynamic range of the embedded ADC
• A resistor, R132, for impedance matching
• DC decoupling capacitor, C106

### 3.3.6 Power Supply System

The PL360G55CB-EK board can be powered by several power sources. Supply the board via:

• the DC jack 2.0 mm connector J8, \( DC\_IN \), with a DC source from 6V to 30V (±5%) and 4.2W
• the USB connector (+5V), J4
• the power supply pin (+5V) of mikroBUS standard

**Table 3-13. Power Sources for PL360G55CB-EK Board**

<table>
<thead>
<tr>
<th>Power Input</th>
<th>Voltage Requirements</th>
<th>Power Requirements</th>
<th>Connector Marking</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC Jack connector</td>
<td>+6V to +30V (±5%)</td>
<td>4.2 Watts</td>
<td>( DC_IN )</td>
</tr>
<tr>
<td>Target USB</td>
<td>+5V</td>
<td>According to USB</td>
<td>USB</td>
</tr>
<tr>
<td>mikroBUS Power pin (+5V)</td>
<td>+5V</td>
<td>According to mainboard specifications</td>
<td>+5V</td>
</tr>
</tbody>
</table>

The PL360G55CB-EK board has two voltage rails:

• +3.3V for the digital part of the PLC modem, PL360, and the SAMG55J19 MCU
• +12V to power the class-D amplifier of the PLC coupling circuit
Note that the PL360G55CB-EK board does not provide a power supply protection circuit; only a TVS diode is used to protect from voltage spikes at the DC rail.

The 12V voltage rail is obtained from the MC16301 buck-boost converter. For a further description about the buck-boost converter see the MCP16301 Buck-Boost Converter User's Guide. If the VDC voltage is always higher than 12V, it is possible to improve the power efficiency by transforming the converter mode from buck-boost to buck, see MCP16301 datasheet for a further explanation.

Figure 3-11. 12V Voltage Design

Restriction: Note that some power sources, such as USB port and mikroBUS rail, might have limited current capabilities and they could not supply enough current for the class-D amplifier transmitting against low impedance values. In this case, an external AC/DC power supply with enough current rating is recommended to maintain the PLC performance at its best. In case of using one, we recommend a module complying to national regulations or CISPR 32:2015.

Another buck converter, MC16301, is used to generate a regulated 3.3V voltage rail required by the PL360 modem and the SAMG55J19 MCU. For a further description about the buck converter see the MCP16301 Buck Converter User's Guide.

Figure 3-12. 3.3V Buck Converter Design

There are one LED and two test points on each voltage rail to check whether all power supplies are operating properly.

To avoid on board self-generated disturbances within the PLC signal band, both converters are switching at 500 kHz fixed frequency, out of the PLC band (95 to 125 kHz).
Tip: In case of choosing a different SMPS in the customer design, it is important to analyze its potential interference on the PLC frequency band.

Attention: To avoid noise interferences, the switching frequency of the SMPS must be out of the PLC band and preferably in frequencies above it to avoid harmonics influence. This is essential to obtain a good reception performance.

3.3.6.1 PLC Rejection Filter

When the PLC coupling circuit is in parallel with the power supply circuit, the input impedance of the final equipment could be affected. If the requirements about total input impedance are not satisfied, an appropriate input filter is needed at the power supply input to increase the input impedance.

Apart from the input filter, it is also recommended to add a PLC rejection filter to avoid the absorption of the PLC signals by the power supply circuit. This filter also increases the input impedance, so it helps to achieve the requisites about input impedance.

Notice: The PL360G55CB-EK board has PLC coupling and power supply circuits separated, so the PLC rejection filter is not included. A PLC rejection filter is needed in case of low input impedance after connecting in the same point the PLC Coupling connector J1 and the power source of the board.

An example of PLC rejection filter is composed of two inductance in-series (L = 560 μH) and a capacitor in-parallel (C = 100 nF) at the power supply input as shown in the following picture.

Figure 3-13. PLC Rejection Filter Example
3.3.7 Zero-Crossing Detector Circuit

Phase identification is an important feature of devices that are connected to a Smart Grid network. A typical implementation is based on measuring the time difference between a specific PLC frame reception and the last zero crossing event of the mains single-phase to which the device is connected.

**Important:** The phase identification feature is mandatory for G3-PLC and PRIME1.4, but not for PRIME1.3.

Figure 3-14 shows the Zero-Crossing Detection circuit used in the PL360G55CB-EK board, which features detection of rising edges of the mains voltage. The output signal of the detection circuit "VZ CROSS" is connected to VZ pin of PL360 and a synchronization algorithm is applied in order to obtain an accurate measurement of the time between PLC frame reception and zero crossing events.

**Figure 3-14. Zero-Crossing Detection Circuit**

![Zero-Crossing Detection Circuit Diagram]

**Notice:** Designs that do not require galvanic isolation can use a simpler Zero-Crossing Detector circuit, such as a Zener diode, instead of the previous circuit.

3.4 Hardware Description – MCU Peripherals

3.4.1 Voltage Monitor

The input pin PA19 of SAMG55J19 is used to monitor the 3.3V voltage rail through external voltage divisors. It can be used to monitor the VDC voltage rail mounting R14 and removing R15 resistor.

**Important:** The R14 resistor value depends on the voltage value of the input source power.
The voltage monitor circuit allows the implementation of multiple applications such as:

- Detection of fault conditions
- Detection of Low-Power mode entering conditions
- Detection of wake-up situations

### 3.4.2 LEDs and Buttons

The PL360G55CB-EK board is equipped with several LEDs and one user push button.

#### 3.4.2.1 User LEDs

The PL360G55CB-EK board includes two general purpose LEDs, one green connected to PA12 (LED0) and one red connected to PA15 (LED1).

#### 3.4.2.2 Push Buttons

The PL360G55CB-EK board is equipped with a momentary push button switch mounted directly to the board. When the button is pressed it will drive the SAMG55 reset line, NRST, to GND. And PA29 will drive the PL360 reset line, NRST_PL360, to GND.

### 3.4.3 Chip Programming

The 1x2 pin-header J2 marked as “PROG” is connected to the SAMG55J19 chip input pin (PA18) and GND. This header can be used to upgrade (using a bootloader binary file of the SAMG55J19) the PLC stack running on the SAMG55 by the USB/serial port. See *Smart Energy: Serial Bootloader User Guide* for more information.
3.4.4 Chip Erase

The 1x2 pin-header J3 marked as “ERASE” is connected to the SAMG55J19 chip erase pin (PB12) and 3.3V. This header can be used to re-initialize the Flash content (and some of its NVM bits) to an erased state (all bits read as logic level 1) by placing a jumper on the header and pressing the reset switch button. After a while, the erase jumper should be removed and the PCBA must be turned off and turned on by disconnecting and connecting it again to the selected power supply. See section “ERASE Pin” in the SAMG55J19 datasheet for more information.

**Notice:** Take into account that when Flash is erased, the bootloader application will also be removed; therefore the SAMG55J19 device will be programmable only via JTAG.

3.5 Hardware Description – MCU Interface Ports

3.5.1 USB Device Port

The USB Device Port (UDP) is compliant with the Universal Serial Bus (USB) 2.0 full-speed device specification. There is a USB available on the PL360G55CB-EK board that can act as both host and device. It has a Micro-B female USB connector with the silk screen USB.

The I/O line PA11 allows the application to check if VUSBD is available.

**Figure 3-18. USB Circuit**

**Important:** Check online resources from the Microchip Website to download the drivers according to your Operating System.

**CAUTION** The USB connector is not isolated from mains. Please make use of proper isolation (i.e.: USB isolator device) in case of using this connector when the board is not galvanically isolated (using a PLC Coupling design which it is not isolated from mains). Take into account the possible noise interference that these isolators could be adding to the PLC network. For instance, you can use the UH401.
3.5.2 SAMG55J SWD/JTAG Port

The PL360G55CB-EK board includes an SWD (Serial Wire Debug) / JTAG interface port to provide debug level access to the system-on-chip. It also embeds a serial wire trace. This connector provides the required interface for in-circuit emulators, like the Atmel-ICE or SAM-ICE. The SW-DP/JTAG port is a 10-pin, dual row, 0.1-inch male connector (J7). When using the SAM-ICE, a JTAG adapter for 20 to 10 pins is necessary, e.g., this one.

**Important:** Note that the PL360G55CB-EK kit does not include either Atmel SAM-ICE or Atmel-ICE JTAG emulators.

Please refer to the SAMG55 datasheet for further description of the JTAG debug port.

**Figure 3-19. JTAG/SWD Interface Schematic**

![JTAG/SWD Interface Schematic](image)

The JTAG/SWD connector is not isolated from mains. Please make use of proper isolation (i.e.: USB isolator device) if using this connector when the board is not galvanically isolated (using a PLC Coupling design which it is not isolated from mains). Take into account the possible noise interference that these isolators could be adding to the PLC network. For instance, you can use the UH401.

3.5.3 mikroBUS Connector

The PL360G55CB-EK board incorporates mikroBUS add-on connectors (J5 and J6) to integrate the board itself as a module which is able to interface with other microcontrollers or microprocessors (main board).

The mikroBUS standard specifies the size and shape of the add-on boards, but because of special constraints, the board exceeds those limits although keeping the smallest size model S as a reference for the plug-in area.

The PL360G55CB-EK board is designed to operate only from the +5V power supply rail of the mikroBUS socket. Therefore, +3.3V power supply pin is not connected.

**Important:** By default, J5 and J6 headers are not populated in the board. The 8-pin headers are included in a zip bag as kit contents.

This mikroBUS standard has a pair of 1x8 male headers with the following pinout:
• SPI
• UART
• I²C
• PWM
• Interrupt
• Analog input
• Reset
• Chip Select
• +3.3V
• +5V
• Two GND pins

Figure 3-20. mikroBUS Connector

Notice: The mikroBUS Xplained Pro is an extension board which contains the female header to connect the mikroBUS add-on boards to the Xplained Pro MCU boards.

3.6 PL360G55CB-EK Schematics
This section contains the schematics for the PL360G55CB-EKv2 board:

• Top Level Schematic, Figure 3-21
• PL360 Schematic, Figure 3-22
• SAMG55 MCU Schematic, Figure 3-23
• Interface and Peripherals SAMG55 Schematic, Figure 3-24
• Power Supply Schematic, Figure 3-25
• PLC Coupling Schematic, Figure 3-26
Figure 3-21. Top Level Schematic

Figure 3-22. PL360 Schematic
Figure 3-23. SAMG55 MCU Schematic

Figure 3-24. Interface and Peripherals SAMG55 Schematic

The PROG pin has an internal pull-up if not configured as GPIO in the user application.
Figure 3-25. Power Supply Schematic

Power Supply

 PLC Coupling Schematic

Figure 3-26. PLC Coupling Schematic

Note: See DS52020 User’s Guide for more information about 12V converter.

Also, in the case of a DC bus, please respect the board polarity andNever expose traces on the back side of the FR4 circuit board. The 3V3 and 12V should never be connected through the USB or JTAG port, it will be required to add adequate performance, only when VIN is performed with a limited power. Therefore, for the power bus, as well as over the lifetime of the converter, it will be required to add adequate power to the converter. A +5V source can be used to power the whole board:

Three power inputs can be used to power the whole board:

- DC jack connector (6V to 30V)
- 5 Volts of mikroBUS interface
- USB Device

Power the whole board:

Note: See DS52020 User’s Guide for more information about 12V converter.
3.7 PL360G55CB-EK Layout

This section contains the layout graphics for the PL360G55CB-EKv2 board:

- Layer 1: Top Layer, Figure 3-27
- Layer 2: Mid Layer 1 (Ground), Figure 3-28
- Layer 3: Mid Layer 2 (Power Supplies), Figure 3-29
- Layer 4: Bottom Layer, Figure 3-30
- Top Components Placement, Figure 3-31
- Bottom Components Placement, Figure 3-32

Figure 3-27. PL360G55CB-EKv2 Layout: Top Layer
Figure 3-28. PL360G55CB-EKv2 Layout: Mid Layer 1 (Ground)
Figure 3-29. PL360G55CB-EKv2 Layout: Mid Layer 2 (Power Supplies)
Figure 3-30. PL360G55CB-EKv2 Layout: Bottom Layer
Figure 3-31. PL360G55CB-EKv2 Layout: Top Silkscreen
Figure 3-32. PL360G55CB-EKv2 Layout: Bottom Silkscreen
4. **Compliance for Specific Standards**

The development/evaluation tool is designed to be used for research and development in a laboratory environment. This development/evaluation tool is not intended to be a finished appliance, nor is it intended for incorporation into finished appliances that are made commercially available as single functional units to end users.

The PL360G55CB-EK board is a CE mark product which passes the EN 50065-1, EN 50065-2-3, EN 50065-7 EMC standards. It also satisfies the Pb-Free and ROHS directive.
5. References

• CENELEC, EN 50065. Signaling on low-voltage electrical installations in the frequency range 3 kHz to 148.5 kHz, 2002
• PL360 Datasheet, 2018
• SAMG55 Datasheet, 2016
• MCP16301 High-Voltage Input Integrated Switch Step-Down Regulator, 2015
• MCP16301 High Voltage Buck Converter 600mA Demo Board User’s Guide, 2011
6. **Revision History**

6.1 **Rev A - 04/2019**

<table>
<thead>
<tr>
<th>Document</th>
<th>Initial release.</th>
</tr>
</thead>
</table>

© 2019 Microchip Technology Inc.
The Microchip Web Site

Microchip provides online support via our web site at http://www.microchip.com/. This web site is used as a means to make files and information easily available to customers. Accessible by using your favorite Internet browser, the web site contains the following information:

- **Product Support** – Data sheets and errata, application notes and sample programs, design resources, user’s guides and hardware support documents, latest software releases and archived software
- **General Technical Support** – Frequently Asked Questions (FAQ), technical support requests, online discussion groups, Microchip consultant program member listing
- **Business of Microchip** – Product selector and ordering guides, latest Microchip press releases, listing of seminars and events, listings of Microchip sales offices, distributors and factory representatives

Customer Change Notification Service

Microchip’s customer notification service helps keep customers current on Microchip products. Subscribers will receive e-mail notification whenever there are changes, updates, revisions or errata related to a specified product family or development tool of interest.


Customer Support

Users of Microchip products can receive assistance through several channels:

- Distributor or Representative
- Local Sales Office
- Field Application Engineer (FAE)
- Technical Support

Customers should contact their distributor, representative or Field Application Engineer (FAE) for support. Local sales offices are also available to help customers. A listing of sales offices and locations is included in the back of this document.

Technical support is available through the web site at: http://www.microchip.com/support

Microchip Devices Code Protection Feature

Note the following details of the code protection feature on Microchip devices:

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip’s Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as “unbreakable.”

Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip’s code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

Legal Notice

Information contained in this publication regarding device applications and the like is provided only for your convenience and may be superseded by updates. It is your responsibility to ensure that your application meets with your specifications. MICROCHIP MAKES NO REPRESENTATIONS OR WARRANTIES OF ANY KIND WHETHER EXPRESS OR IMPLIED, WRITTEN OR ORAL, STATUTORY OR OTHERWISE, RELATED TO THE INFORMATION, INCLUDING BUT NOT LIMITED TO ITS CONDITION, QUALITY, PERFORMANCE, MERCHANTABILITY OR FITNESS FOR PURPOSE. Microchip disclaims all liability arising from this information and its use. Use of Microchip devices in life support and/or safety applications is entirely at the buyer’s risk, and the buyer agrees to defend, indemnify and hold harmless Microchip from any and all damages, claims, suits, or expenses resulting from such use. No licenses are conveyed, implicitly or otherwise, under any Microchip intellectual property rights unless otherwise stated.

Trademarks

The Microchip name and logo, the Microchip logo, AnyRate, AVR, AVR logo, AVR Freaks, BitCloud, chipKIT, chipKIT logo, CryptoMemory, CryptoRF, dsPIC, FlashFlex, flexPWR, Heldo, JukeBlox, KeeLoq, Kleer, LANCheck, LINK MD, maXSylus, maXTouch, MediaLB, megaAVR, MOST, MOST logo, MPLAB, OptoLyzer, PIC, picoPower, PICSTART, PIC32 logo, Prochip Designer, QTouch, SAM-BA, SpyNIC, SST, SST Logo, SuperFlash, tinyAVR, UNI/O, and XMEGA are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

ClockWorks, The Embedded Control Solutions Company, EtherSynch, Hyper Speed Control, HyperLight Load, IntelliMOS, mTouch, Precision Edge, and Quiet-Wire are registered trademarks of Microchip Technology Incorporated in the U.S.A.


SQTP is a service mark of Microchip Technology Incorporated in the U.S.A.

Silicon Storage Technology is a registered trademark of Microchip Technology Inc. in other countries.

GestIC is a registered trademark of Microchip Technology Germany II GmbH & Co. KG, a subsidiary of Microchip Technology Inc., in other countries.

All other trademarks mentioned herein are property of their respective companies.
Quality Management System Certified by DNV

ISO/TS 16949
Microchip received ISO/TS-16949:2009 certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona; Gresham, Oregon and design centers in California and India. The Company’s quality system processes and procedures are for its PIC® MCUs and dsPIC® DSCs, KEELQ® code hopping devices, Serial EEPROMs, microperipherals, nonvolatile memory and analog products. In addition, Microchip’s quality system for the design and manufacture of development systems is ISO 9001:2000 certified.
Worldwide Sales and Service

<table>
<thead>
<tr>
<th>AMERICAS</th>
<th>ASIA/PACIFIC</th>
<th>ASIA/PACIFIC</th>
<th>EUROPE</th>
</tr>
</thead>
</table>
| Corporate Office<br>2355 West Chandler Blvd.<br>Chandler, AZ 85224-6199<br>Tel: 480-792-7200<br>Fax: 480-792-7277<br>Technical Support: http://www.microchip.com/support<br>Web Address: www.microchip.com<br>Atlanta<br>Duluth, GA<br>Tel: 678-957-9614<br>Fax: 678-957-1455<br>Boston<br>Westborough, MA<br>Tel: 774-760-0087<br>Fax: 774-760-0088<br>Chicago<br>Itasca, IL<br>Tel: 630-285-0071<br>Fax: 630-285-0075<br>Dallas<br>Addison, TX<br>Tel: 972-818-7423<br>Fax: 972-818-2924<br>Detroit<br>Novi, MI<br>Tel: 248-848-4000<br>Houston, TX<br>Tel: 281-894-5983<br>Indianapolis<br>Noblesville, IN<br>Tel: 317-773-8323<br>Fax: 317-773-5453<br>Los Angeles<br>Mission Viejo, CA<br>Tel: 949-462-9523<br>Fax: 949-462-9608<br>Tel: 951-273-7800<br>Raleigh, NC<br>Tel: 919-844-7510<br>New York, NY<br>Tel: 631-435-6000<br>San Jose, CA<br>Tel: 408-735-9110<br>Tel: 408-436-4270<br>Canada - Toronto<br>Tel: 905-695-1980<br>Fax: 905-695-2078 | Australia - Sydney<br>Tel: 61-2-9868-6733<br>China - Beijing<br>Tel: 86-10-8569-7000<br>China - Chengdu<br>Tel: 86-28-8665-5511<br>China - Chongqing<br>Tel: 86-23-8980-9588<br>China - Dongguan<br>Tel: 86-769-8702-9880<br>China - Guangzhou<br>Tel: 86-20-8755-8029<br>China - Hangzhou<br>Tel: 86-571-8792-8115<br>China - Hong Kong SAR<br>Tel: 852-2943-5100<br>China - Nanjing<br>Tel: 86-25-8473-2460<br>China - Qingdao<br>Tel: 86-66-8502-7355<br>China - Shanghai<br>Tel: 86-21-3326-8000<br>China - Shenyang<br>Tel: 86-24-2334-2829<br>China - Shenzhen<br>Tel: 86-755-8864-2200<br>China - Suzhou<br>Tel: 86-186-6233-1526<br>China - Wuhan<br>Tel: 86-27-5980-5300<br>China - Xiamen<br>Tel: 86-952-2388138<br>China - Zhuhai<br>Tel: 86-755-3210040 | India - Bangalore<br>Tel: 91-80-3090-4444<br>India - New Delhi<br>Tel: 91-11-4160-8631<br>India - Pune<br>Tel: 91-20-4121-0141<br>Japan - Osaka<br>Tel: 81-6-6152-7160<br>Japan - Tokyo<br>Tel: 81-3-6880-3770<br>Korea - Daegu<br>Tel: 82-53-744-4301<br>Korea - Seoul<br>Tel: 82-2-554-7200<br>Malaysia - Kuala Lumpur<br>Tel: 60-3-7651-7906<br>Malaysia - Penang<br>Tel: 60-4-227-8870<br>Philippines - Manila<br>Tel: 63-2-634-9065<br>Singapore<br>Tel: 65-6334-8870<br>Taiwan - Hsin Chu<br>Tel: 886-3-577-8366<br>Taiwan - Kaohsiung<br>Tel: 886-7-213-7830<br>Taiwan - Taipei<br>Tel: 886-2-2506-8600<br>Thailand - Bangkok<br>Tel: 66-2-694-1351<br>Vietnam - Ho Chi Minh<br>Tel: 84-28-5448-2100 | Austria - Wels<br>Tel: 43-7242-2244-39<br>Denmark - Copenhagen<br>Tel: 45-4450-2828<br>Finland - Espoo<br>Tel: 358-9-4520-820<br>France - Paris<br>Tel: 33-1-69-53-63-20<br>Germany - Garching<br>Tel: 49-8931-9700<br>Germany - Haan<br>Tel: 49-2129-3766400<br>Germany - Heilbronn<br>Tel: 49-711-67-3636<br>Germany - Karlsruhe<br>Tel: 49-721-625370<br>Germany - Munich<br>Tel: 49-89-627-144-0<br>Germany - Rosenheim<br>Tel: 49-8031-354-560<br>Israel - Ra'anana<br>Tel: 972-9-744-7705<br>Italy - Milan<br>Tel: 39-0331-742611<br>Italy - Padova<br>Tel: 39-049-7625286<br>Netherlands - Drunen<br>Tel: 31-416-690399<br>Norway - Trondheim<br>Tel: 47-72884388<br>Poland - Warsaw<br>Tel: 48-22-3325737<br>Romania - Bucharest<br>Tel: 40-21-407-87-60<br>Spain - Madrid<br>Tel: 34-91-708-08-90<br>Sweden - Gothenberg<br>Tel: 46-31-704-60-40<br>Sweden - Stockholm<br>Tel: 46-8-5090-4654<br>UK - Wokingham<br>Tel: 44-118-921-5800<br>Fax: 44-118-921-5820