Low Level C programming for Designers

LARS BENGTSSON, FPGA WORLD 2015
Low Level C Programming for Designers
2015
Lars Bengtsson and Lennart Lindh
Editor Mia Lindh

http://lowlevelcprogramming.agstu.com/
LowLevel C programming for Designers

• C programming for embedded systems on FPGAs
• Inexpensive hardware.
• Tutorials/Case studies.
Hardware

DE2-115: $595

BEMICRO MAX 10: $30
MAX10: FPGA from Altera

MAX 10 FPGA:

- Supports Nios II gen 2
- On-chip analog block (ADC, temp sens)
- On-chip DSP block (18x18 multiplier)
- Supports DDR3 (Double Data Rate)
- On-chip User-flash (55 nm NOR, “instant on”)
- SRAM, PLLs, 250 I/O pins, 8000 LE
- ....
BeMicro MAX 10 from Arrow

However..., no VGA support!
Pmod

Pmod™: Registered trademark of Diligent Inc.

<table>
<thead>
<tr>
<th>Pin</th>
<th>Signal</th>
<th>Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>IO1</td>
<td>In/Out</td>
</tr>
<tr>
<td>2</td>
<td>IO2</td>
<td>In/Out</td>
</tr>
<tr>
<td>3</td>
<td>IO3</td>
<td>In/Out</td>
</tr>
<tr>
<td>4</td>
<td>IO4</td>
<td>In/Out</td>
</tr>
<tr>
<td>5</td>
<td>GND</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>VCC</td>
<td></td>
</tr>
</tbody>
</table>
Pmod

- **PmodGYRO**
  - Gyroscope
  - Low power
  - 5 V operating voltage
  - Ships with 6-pin header

- **PmodLED**
  - LED
  - 5 V operating voltage
  - Ships with 6-pin header

- **PmodHEB**
  - LED
  - 5 V operating voltage
  - Ships with 6-pin header

- **PmodIO2S**
  - I/O
  - 5 V operating voltage
  - Ships with 6-pin header

- **PmodIA**
  - Analog
  - 5 V operating voltage
  - Ships with 6-pin header

- **PmodTCK**
  - Clock
  - 5 V operating voltage
  - Ships with 6-pin header

- **PmodKYO**
  - Keyboard
  - 5 V operating voltage
  - Ships with 6-pin header

- **PmodLED**
  - LED
  - 5 V operating voltage
  - Ships with 6-pin header

- **PmodLS1**
  - Latch
  - 5 V operating voltage
  - Ships with 6-pin header

- **PmodAWS**
  - AWS
  - 5 V operating voltage
  - Ships with 6-pin header

- **PmodMIC**
  - Microphone
  - 5 V operating voltage
  - Ships with 6-pin header

- **PmodMIC103**
  - Microphone
  - 5 V operating voltage
  - Ships with 6-pin header

- **PmodO1**
  - Output
  - 5 V operating voltage
  - Ships with 6-pin header

- **PmodOD1**
  - Output
  - 5 V operating voltage
  - Ships with 6-pin header

- **PmodLED**
  - LED
  - 5 V operating voltage
  - Ships with 6-pin header

- **PmodPMON1**
  - Power Monitor
  - 5 V operating voltage
  - Ships with 6-pin header

- **PmodPS2**
  - PS/2
  - 5 V operating voltage
  - Ships with 6-pin header

- **PmodRS232**
  - RS-232
  - 5 V operating voltage
  - Ships with 6-pin header

- **PmodRS485**
  - RS-485
  - 5 V operating voltage
  - Ships with 6-pin header

- **PmodRTCC**
  - Real Time Clock
  - 5 V operating voltage
  - Ships with 6-pin header

- **PmodSD**
  - SD Card
  - 5 V operating voltage
  - Ships with 6-pin header

- **PmodDSF**
  - Digital Switch
  - 5 V operating voltage
  - Ships with 6-pin header

- **PmodDSI**
  - Digital I/O
  - 5 V operating voltage
  - Ships with 6-pin header

- **PmodSTEP**
  - Stepper Motor
  - 5 V operating voltage
  - Ships with 6-pin header

- **PmodSW1**
  - Switch
  - 5 V operating voltage
  - Ships with 6-pin header

- **PmodSTC1**
  - Temperature
  - 5 V operating voltage
  - Ships with 6-pin header

- **PmodTMP2**
  - Temperature
  - 5 V operating voltage
  - Ships with 6-pin header

- **PmodTMS3**
  - Temperature
  - 5 V operating voltage
  - Ships with 6-pin header

---

**PmodGPS - GPS Receiver**

- Satellite positioning accuracy for your designs
- 3 meter 2D accuracy without aid
- Super low power consumption (24mA tracking and 30mA during acquisition)
- Integrated ceramic GPS antenna

Price: $49.00

Add to Cart

**PmodOLED - Organic LED Graphic Display**

- 128 by 32 pixel 0.9" OLED display
- Standard SPI interface
- Clock speeds of up to 10MHz
- Internal display buffer

Price: $27.99

Add to Cart

**PmodWiFi - 802.11b WIFI Interface**

- IEEE 802.11-compliant RF transceiver
- Serialised unique MAC address
- 1 and 2Mbps data rates
- IEEE 802.11b/g/n-compatible
- Integrated PCB antenna
- Range: up to 400m (1300 ft)

Price: $52.00

Add to Cart
VGA?

http://www.xess.com/blog/a-simple-vga-interface-for-the-xula-fpga-board/

32x32x32 = colors
VGA?

2x2x2 = 8 colors

http://www.xess.com/blog/a-simple-vga-interface-for-the-xula-fpga-board/
VGA-Pmod adapter
Low Level C Programming

Chapter 1. Overview

✓ Embedded computer system
✓ Hardware-Software interaction
✓ Hierarchical models and abstraction levels
✓ Applications and API
✓ Development tools
Low Level C Programming

Chapter 2. Hardware and software installation

✓ Quartus
✓ Nios
✓ BeMicro MAX 10
Low Level C Programming

Chapter 3. CASE 1

✓ CASE 1A: Hello World
✓ CASE 1B: Debugging
✓ CASE 1C: PIO, HAL, memory mapping, bit manipulation
Chapter 4. CASE 2

- Theory: Computer memories (RAM, ROM, Flash, Cache...)
- SDRAM controller
- CASE 2: Add an external SDRAM memory
Low Level C Programming

Chapter 5. CASE 3

- Writing device drivers
- SW-HW interface
- Platform independent application code
- Hardware Abstraction Level
- BSP integration: ticle-files
- Introduction to IP component design
Chapter 6. CASE 4

✓ Optimizing C code
✓ User responsibility: overall structure
✓ Compiler optimization: details
✓ Scope of variables, natural-size, unsigned
✓ Volatile and register declarations, type matching
✓ Avoid writing code that generates temporary variables
✓ Use of macros, ”static” declaration of functions
✓ switch versus if-then
Low Level C Programming

Chapter 7. CASE 5

✓ Polling and Interrupt
✓ CASE 5A: Polling
✓ CASE 5B: Interrupt
✓ Non-vectored (IIC) versus vectored (EIC)
✓ Context saving: Interrupts versus multi-tasking
✓ HAL interrupt service: legacy versus enhanced
Chapter 8. CASE 6

- Analog signals
- ADC: flash, **SAR**, dual slope
- Theory: resolution, quantization and quantization error
- Theory: sampling, sampling rate, sampling theorem
- MAX 10 ADC: ”sequence”, ”sequencer”
- BeMicro board: LDR, temperature sensor
Low Level C Programming

Version 2.0?

Chapter X: Inserting assembler code in C
Chapter X: Structured C programming (hierarchies in C)
Chapter X: State machines in C
Chapter X: Introduction to multi-tasking

Chapter X: Flash memory
Chapter X: Sensors with digital interface (SPI)
Chapter X: Introduction to DSP (filters: Pmod with microphone and speaker)
Expansion connectors: 80-pin & 40-pin