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ENGINEERING BUSINESS INFORMATICS
Campus Künzelsau
Reinhold-Würth-Hochschule

Chapter 3: Development tools and software support

Stellaris® Cortex™-M3 - Microcontroller Family

Texas Instruments

Texas Instruments - University Program

Heilbronn University, Campus Künzelsau

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Content

- Chapter 3: Development tools and software support
  - 3.1 Evaluation boards
  - 3.2 Software development tools
  - 3.3 C language: Introduction
  - 3.4 StellarisWare®
- **Topics:** EKS-LM3S1968, user LED, switches, OLED, hibernation module debugging, JTAG, USB device controller

Learning Objectives

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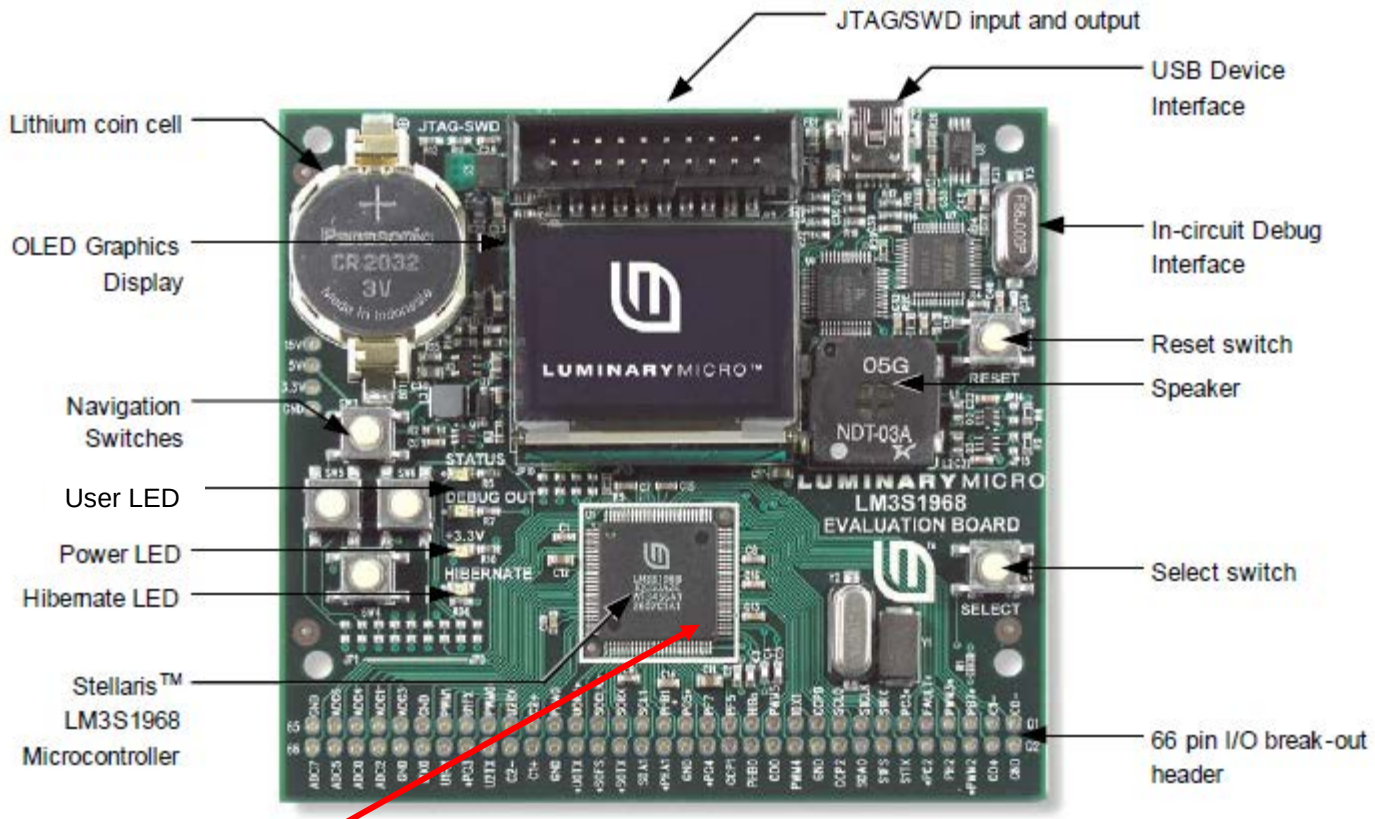
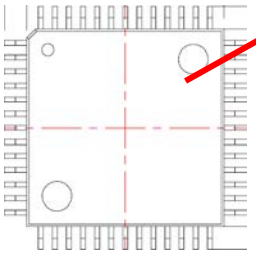
- The chapter describes the basics (theory) of the Stellaris® EKS-LM3S1968.
- The Evaluation Kit uses a LM3S1968 microcontroller.
- Link: Chapter 5.1 “From Stellaris®1000 family to Stellaris® 9000 family” introduces the EKS-LM3S9B92 Evaluation Kit
- Structure and questions:
  - What does the architecture look like?
  - Why are Embedded Systems peripherals?
  - What are the optical and acoustical opportunities?
  - What are the Debugging and USB interfaces?

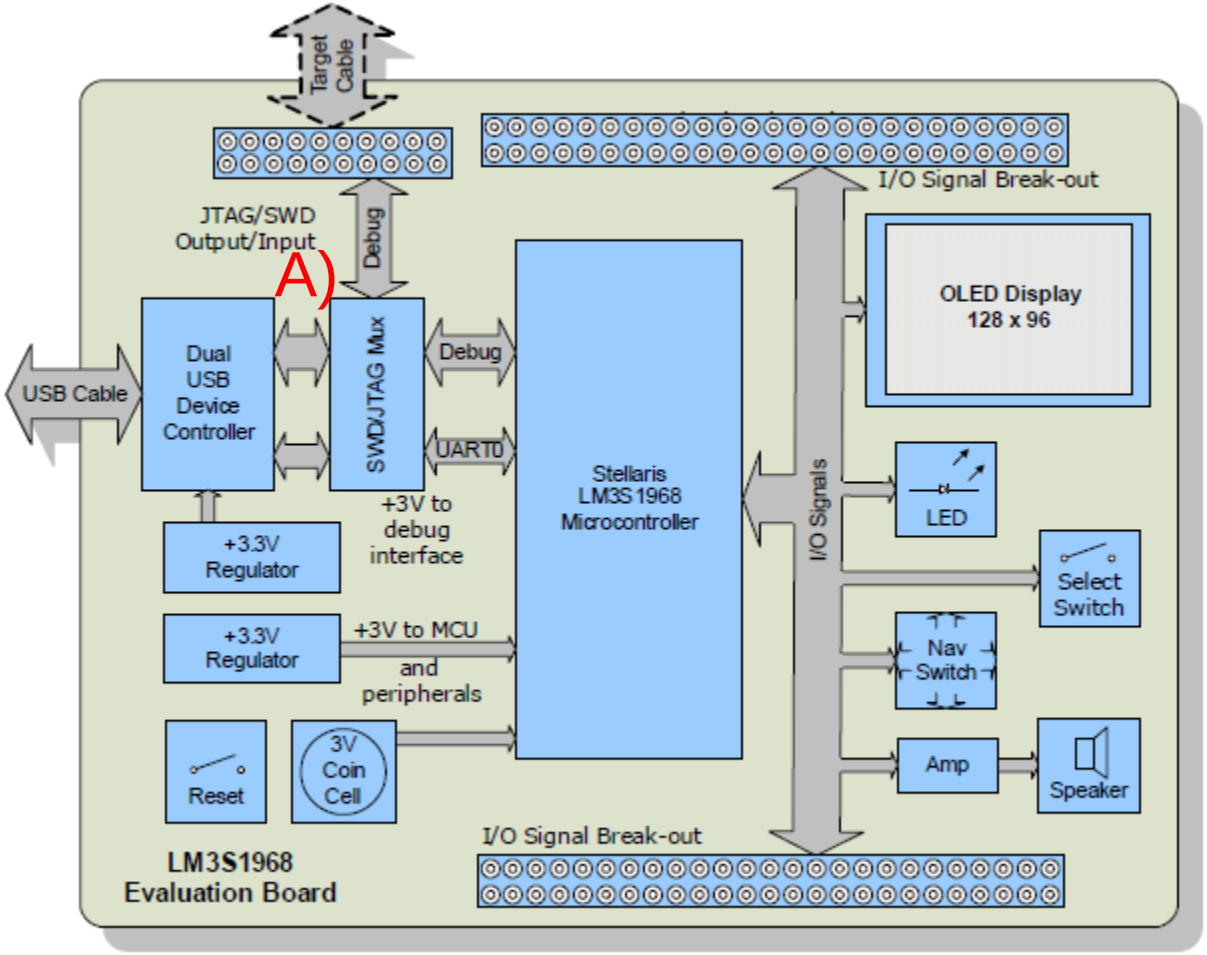
LM3S1968 Evaluation Board





- **100-Pin LQFP Package**

Block Diagram



Main Features

- The Stellaris® LM3S1968 Evaluation Board (EVB) is a compact and versatile evaluation platform for the Stellaris® LM3S1968 ARM Cortex™-M3-based microcontroller.
- The evaluation kit design highlights the LM3S1968 microcontroller's peripherals and its Hibernation module.
- A 3V lithium battery, included in the kit, supplies power to the Hibernation module and maintains data and real-time clock information for approximately two years in the absence of USB power.
- You can use the EVB either as an evaluation platform or as a low-cost in-circuit debug interface (ICDI).
- In debug interface mode, the on-board microcontroller is disabled, allowing connection of the debug signals to an external Stellaris® microcontroller target. The kit is also compatible with high-performance external JTAG debuggers.
- This evaluation kit enables quick evaluation, prototype development, and creation of application-specific designs using the LM3S1968's broad range of peripherals.

Main Features (cont.)

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- Stellaris® LM3S1968 microcontroller
- Simple setup; USB cable provides serial communication, debugging, and power
- OLED graphics display with 128 x 96 pixel resolution
- User LED, navigation switches, and select pushbuttons
- 8Ω magnetic speaker with class D amplifier
- Internal 3V battery and support for on-chip hibernation module
- USB interface for debugging and power supply
- Standard ARM 20-pin JTAG debug connector with input and output modes
- LM3S1968 I/O available on labeled break-out pads

Hardware Description

- Hibernation Module
  - Manages removal and restoration of power to the microcontroller and peripherals while maintaining a real-time clock (RTC) and non-volatile memory.
  - The EVB includes a 3 V Lithium battery to maintain Hibernate module power when USB power is unavailable.
  - Note: Pressing the Select switch on the EVB asserts WAKE. The Hibernate LED (LED4) signals that the EVB is in Hibernate state (+3.3V disabled) as long as USB power is present. When USB power is removed, the EVB will remain in the Hibernate state, however, the LED will not be on.
- Clocking
  - The EVB uses an 8.0MHz crystal to complete the LM3S1968 microcontroller's main internal clock circuit.
  - An internal PLL, configured in software, multiples this clock to 50 MHz for core and peripheral timing.

Hardware Description (cont.)

- Organic LED Display (OLED)
  - The EVB features an OLED graphics display with 128 x 96 pixel resolution.
  - OLED is a new technology that offers many advantages over LCD display technology. The display is protected during shipping by a thin, protective plastic film. The film can be removed using a pair of tweezers.
  - Features
    - RiT Display P14201 series display
    - 128 columns by 96 rows
    - High-contrast (typically 500:1)
    - Excellent brightness (120 cd/m2)
    - Fast 10 µs response
  - Control Interface
    - The OLED display has a built-in controller IC with synchronous serial and parallel interfaces.
    - Synchronous serial (SSI) is used on the EVB as it requires fewer microcontroller pins.
    - Data cannot be read from the OLED controller; only one data line is necessary.
- Note: The Stellaris® Firmware Development Package contains complete drivers with source-code for the OLED display.
- Link: see Chapter 3.4 “StellarisWare®”

Hardware Description (cont.)

- Push Switches
  - The EVB has five general-purpose input switches. Four are arranged in a navigation-style configuration. The fifth functions as a Select switch on PG7. The Select switch also connects to the WAKE signal of the Hibernate module which has an internal pull-up resistor. A diode (D2) blocks current into the PG7 pin when in the Hibernate state.
- Speaker
  - The LM3S1968 evaluation board's speaker circuit can be used in either tone or waveform mode.
  - In tone mode, the LM3S1968 microcontroller's PWM module directly generates tones within the audible frequency range.
  - The width of the pulses determines the volume. If only one PWM signal (PWM2 or PWM3) is used, the non-PWM signal should be configured as a general-purpose output. For increased speaker volume, PWM2 and PWM3 can be configured as complementary drive signals. In tone mode, be careful to avoid large DC currents in the speaker.
  - Waveform mode uses two high-frequency PWM signals to drive a MOSFET H-bridge with an output filter. This circuit is essentially a Class-D amplifier.

Hardware Description (cont.)

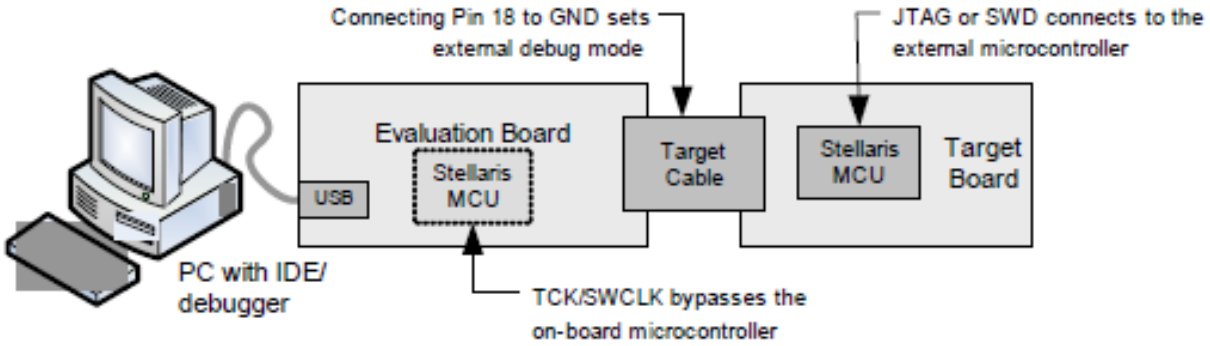
- User LED
  - A user LED (LED) is provided for general use. The LED is connected to PG2/PWM0, allowing the option of either GPIO or PWM control (brightness control).
- Power Supplies
  - In normal operating mode, the LM3S1968 is powered from a +3.3V supply.
  - A low drop-out (LDO) regulator converts +5V power from the USB cable to +3.3V. The +3.3V power is available for powering external circuits.

Debugging

- Debugging
  - Stellaris® microcontrollers support programming and debugging using either JTAG or SWD.
  - Joint Test Action Group (JTAG) uses the signals TCK, TMS, TDI, and TDO.
  - Serial-Wire Debug (SWD) requires fewer signals (SWCLK, SWDIO, and, optionally, SWO, for trace).
  - The debugger determines which debug protocol is used.
  - Note: Default mode is internal ICDI (in-circuit debug interface). Debug on-board LM3S1968 microcontroller over USB interface.
- Note: see slide “Block Diagram” A)

Debugging

- Debugging
  - Evaluation board includes an integrated In-Circuit Debug Interface (ICDI).
  - You can use the Evaluation Board either as an evaluation platform or as a low-cost ICDI.
  - In debug interface mode, the on-board microcontroller is disabled, allowing connection of the debug signals to an external Stellaris® microcontroller target.
  - The kit is also compatible with high-performance external JTAG debuggers.
  - ICDI acts as a USB to the JTAG/SWD adaptor, allowing debugging of any external target board that uses a Stellaris® microcontroller.



Isolating On-Board Hardware

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Microcontroller Pin	Microcontroller Assignment	To Isolate, Remove...
Pin 16 PG3	Up switch	JP1
Pin 17 PG2/PWM0	User LED	JP2
Pin 26 PA0/U0RX	Virtual COM port receive	JP4

Microcontroller Pin	Microcontroller Assignment	To Isolate, Remove...
Pin 29 PA3/SSI0FSS	OLED display chip select	JP5
Pin 37 PG6/PHA1	Right switch	JP6
Pin 36 PG7/PHB1	Select switch	JP7
Pin 40 PG5	Left switch	JP8
Pin 41 PG4	Down switch	JP9
Pin 31 PA5/SSI0TX	OLED display data in	JP10
Pin 28 PA2/SSI0CLK	OLED display clock	JP11
Pin 34 PA6/I2C1SCL	OLED display data/control select	JP12
Pin 27 PA1/U0TX	Virtual COM port transmit	JP13
Pin 86 PH0/PWM2	Sound+	JP14
Pin 85 PH1/PWM3	Sound-	JP15

USB Device Controller Functions

- USB Overview
  - An FT2232 device manages USB-to-serial conversion.
  - FT2232 is factory-configured to implement a JTAG/SWD port (synchronous serial) on channel A and a Virtual COM Port (VCP) on channel B.
  - This feature allows two simultaneous communications links between the host computer and the target device using a single USB cable.
- USB to JTAG/SWD
  - The FT2232 USB device performs JTAG/SWD serial operations under the control of the debugger. A Complex Programmable Logic Device (CPLD) multiplexes SWD and JTAG functions and when working in SWD mode, provides direction control for the bi-directional data line.
- Virtual COM Port
  - The Virtual COM Port (VCP) allows Windows applications (such as HyperTerminal) to communicate with UART0 on the LM3S1968 over USB. Once the FT2232 VCP driver is installed, Windows assigns a COM port number to the VCP channel.

Bypassing Peripherals

- The EVB's on-board peripheral circuits use 15 General Purpose Input/Output (GPIO) lines.
- This leaves 31 GPIO lines and 8 ADC channels immediately available for connection to external circuits.
- If an application requires more GPIO lines, then the on-board hardware can be disconnected.
- The EVB is populated with 15 jumper links, which can be cut with a knife to isolate on-board hardware.

EKS-LM3S9B92

- Evaluation Kit delivers a low-cost, compact and versatile evaluation platform for simultaneous Ethernet + USB + CAN connectivity based on the Stellaris® LM3S9B92 microcontroller.
- Link: Chapter 5.1 “From Stellaris® 1000 family to Stellaris® 9000 family” introduces the serial interface peripherals of the LM3S9B92 microcontroller and the Stellaris® EKS-LM3S9B92 Evaluation Kit

Questions and Exercises

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1. Show the different board peripherals.
2. What is Hibernation?
3. What is OLED?
4. What are the Debugging interfaces?

Summary and Outlook

- Summary
  - From Block Diagram to Main Features
  - From Hardware Description to Isolating On-Board Hardware
- Outlook/How to go on?
  - Chapter 3.2 “Software development tools”
    shows the practical use of the Evaluation Board EKS-LM3S1968
  - The software projects of Chapter 4 “Peripheral Programming in C”
    are implemented on the EKS-LM3S1968

References

- [1] Texas Instruments: *User's Guide - Stellaris® LM3S1968 Evaluation Board*. spmu037a.pdf, 2010.