Learn Embedded Systems

Introduction

This document is a collection of resources for learning embedded systems engineering.

☐ Article: "Introduction", Barr Group

☐ Video: "Embedded Systems Overview", YouTube

Table of Contents

Development Environment

Cross Compilation

- ☐ Article: "Compiling, Linking, and Locating", Barr Group

Development Tools

- **IDE**

    - [PlatformIO](#)
    - [Visual Studio Code](#)
    - [VisualGDB](#)

- **Oscilliscopes and Logic Analyzers**

    - [Video: "Setting Up the Analog Discovery 2 Portable Lab Instrument", YouTube](#)

Embedded Hardware

☐ [Article: "Getting to Know the Hardware", Barr Group](#)

☐ [Video: "Computer Hardware", YouTube](#)

☐ [Video: "MSP430 Hardware Overview", YouTube](#)

Computer Architecture

☐ [Video: "Architecture-Software Interface", Coursera](#)

☐ [Video: "Word Size and Data Types", Coursera](#)

- **RISC**

    - [Website: "RISC-V Educational Materials", RISC-V](#)

- **ARM**

    - ☐ [Video: "ARM University, ARM Architecture Fundamentals", YouTube](#)

    - ☐ [Video: "Get to Know the ARM Cortex M7", YouTube](#)

- **Endianness**

    - ☐ [Article: "Big Endian, Little Endian, Endianness: Understanding Byte Arrangements in Digital Systems", All About Circuits](#)

    - ☐ [Video: "Endianness", Coursera](#)

Embedded Platforms

- **Microcontroller**

    - ☐ [PDF: "Introduction to Microcontrollers", Gunther Gridling, Bettina Weiss](#)

- **System on a Chip**

- ○ ☐ Video: "Arm Education Media Launches System-on-Chip Design Online Courses", YouTube

- **Single Board Computer**

  - ○ ☐ Article: "Single-board computer", Wikipedia

- **FPGA**

  - ○ ☐ Article: "How FPGAs work, and why you'll buy one", Embedded Related
  - ○ ☐ Video: "A Look Inside: SoC FPGAs Introduction (Part 1 of 5)", YouTube

Serial Communication

☐ Video: "PROTOCOLS: UART - I2C - SPI - Serial communications #001", YouTube

- **SPI**

  ☐ **SPI on the MSP430**

  - ○ ☐ Video: "SPI - SPI Overview & Implementation on the MSP430", YouTube

  - ○ ☐ Video: "SPI - Sending a Byte as a SPI Master", YouTube

  - ○ ☐ Video: "SPI - Sending a Packet as a SPI Master using UCTXIFG", YouTube

  - ○ ☐ Video: "SPI - Sending a Packet as a SPI Master using STE/SS", YouTube

  - ○ ☐ Video: "SPI - Receiving a Byte as a SPI Master", YouTube

  - ○ ☐ Video: "SPI - Slave Behavior", YouTube

- **I2C**

  ☐ **I2C on the MSP430**

  - ○ ☐ Video: "I2C - What is I-Squared C and why the Resistors?", YouTube

  - ○ ☐ Video: "I2C - Basic Packet Structure", YouTube

  - ○ ☐ Video: "I2C - Addressing Slave Registers", YouTube

  - ○ ☐ Video: "I2C - Master Configuration on the MSP430FR2355", YouTube

  - ○ ☐ Video: "I2C - Adafruit PFC8523 Real-Time-Clock I2C Slave", YouTube

  - ○ ☐ Video: "I2C - RTC-LaunchPad Connection & Making a Simple Probe", YouTube

  - ○ ☐ Video: "I2C - Writing One Byte to an I2C Slave", YouTube

  - ○ ☐ Video: "I2C - Writing a Register Addr + 3 Bytes to I2C Slave", YouTube

  - ○ ☐ Video: "I2C - Reading One Byte from an I2C Slave", YouTube

- ○ ☐ [Video: "I2C - Reading From a Specific Register Address", YouTube](#)

- ○ ☐ [Video: "I2C - Slave Operation", YouTube](#)

- **UART**

  ☐ **UART on the MSP430**

  - ○ ☐ [Video: "The UART - Serial Com Overview", YouTube](#)

  - ○ ☐ [Video: "UART - The UART Standard", YouTube](#)

  - ○ ☐ [Video: "UART - Configuring the UART Tx", YouTube](#)

  - ○ ☐ [Video: "UART - Configuring the Baud Rate", YouTube](#)

  - ○ ☐ [Video: "UART - Transmitting a Byte at 115200 Baud", YouTube](#)

  - ○ ☐ [Video: "UART - Transmitting a Byte at 9600 Baud", YouTube](#)

  - ○ ☐ [Video: "UART - Transmitting a Character to the Terminal", YouTube](#)

  - ○ ☐ [Video: "UART - Transmitting a String to the Terminal", YouTube](#)

  - ○ ☐ [Video: "UART - Transmitting String to the Terminal w/ IRQs", YouTube](#)

  - ○ ☐ [Video: "UART - Configuring the UART Rx", YouTube](#)

  - ○ ☐ [Video: "UART - Receiving Characters from the Terminal", YouTube](#)

- **RS232**

  - ○ ☐ [Video: "What is RS232 and What is it Used for?", YouTube](#)

  - ○ ☐ [Video: "RS-232, RS-422, RS-485: What Are the Differences?", YouTube](#)

- **RS485**

  - ○ ☐ [Video, "RS-485 Circuit Implementation", YouTube](#)

  - ○ ☐ [Video, "What is RS485 and How it's used in Industrial Control Systems?", YouTube](#)

GPIO

☐ [Video: "How GPIO works | General Purpose Input Output | GPIO Behind The Scene", YouTube](#)

☐ [Article: "Introduction to Microcontrollers - Hello World", Embedded Related](#)

☐ [Article: "Introduction to Microcontrollers - More On GPIO", Embedded Related](#)

☐ [Video: "Using GPIO with the MSP430 Microcontroller", YouTube](#)

- **Pin Modes**

- **Pull Up/Down**

  ☐ Article: "Using Pull-Up and Pull-Down Resistors", Stratify Labs

- **Push-Pull**

  ☐ Video: "GPIO Output Configuration | Open Drain configuration | Push Pull configuration", YouTube

- **Open-Drain**

  ☐ Video: "GPIO Output Mode: Working of Open Drain Configuration", YouTube

- **Direction**

  - **Input**

    ☐ Video: "MSP430 - Digital Inputs & Polling", YouTube

  - **Output**

    ☐ Video: "MSP430 - Digital Outputs", YouTube

Analog Input

- **ADC**

  ☐ **Analog-to-Digital Converter on the MSP430**

  - ☐ Video: "Overview of ADCs", YouTube

  - ☐ Video: "The MSP430 ADC & Configuration", YouTube

  - ☐ Video: "Reading Voltage w/ Conversion-Complete Polling", YouTube

  - ☐ Video: "Reading Voltage w/ Conversion-Complete IRQ", YouTube

  - ☐ Video: "Reading Voltage w Conversion-Complete IRQ & LPM", YouTube

Analog Output

- **PWM**

  ☐ Video: "MSP430 - Creating PWM Signals using Timer Compares", YouTube

- **DAC**

  ☐ Article: "About Digital to Analog Converter (DAC) and Its Applications", ElProCus

Timer

☐ Article: "Introduction to Microcontrollers - More Timers and Displays", Embedded Related

- ☐ **MSP430 Timer**

    - ☐ Video: "Timer Overflow using ACLK", YouTube
    - ☐ Video: "Timer Overflow using ACLK + 12-Bit Counter Length", YouTube
    - ☐ Video: "Timer Overflow using SMCLK", YouTube
    - ☐ Video: "Timer Overflow using SMCLK + Divide-by-4 PreScalar", YouTube
    - ☐ Video: "Timer Compares", YouTube
    - ☐ Video: "Timer Captures", YouTube

Constraints

☐ Video: "Optimizing C for Microcontrollers - Best Practices - Khem Raj, Comcast RDK", YouTube

- **Power**

  ☐ Video: "How To Lower AVR Microcontroller Power using Power Reduction Registers", YouTube

  ☐ Video: "Atmel: picoPower Labs - Basic Power-Saving Techniques", YouTube

  ☐ Video: "Microcontroller Design Considerations for Ultra Low Power Applications", YouTube

  ☐ Video: "Ultra Low Power Microcontroller Design", YouTube

- **Memory**

  ☐ Article: "Memory", Barr Group

  ☐ Video: "Interacting with Memory", Coursera

  ☐ Video: "Different Types of Memory in Microcontroller : Flash Memory, SRAM and EEPROM", YouTube

    - **Program (ROM)**

    - **Dynamic (RAM)**

        - ☐ Video: "Tech Talk: Pros and Cons of Dynamic Memory Allocation", YouTube

        - ☐ Article: "How to make a heap profiler", Embedded Related

Embedded Operating Systems

☐ Article: "Operating Systems", Barr Group

- **Bare Metal**

    - ☐ eBook: "Bare-metal C programming on ARM", GitHub

    - ☐ eBook: "Practical Guide to Bare Metal C++", GitBook

- **GNU/Linux**

- **Real Time Operating Systems**

    - Blog: "RTOS", Barr Group

Embedded Software

☐ Video: "Computer Software", YouTube

☐ Video: "MSP430 Software Overview", YouTube

☐ Important Programming Concepts (Even on Embedded Systems)

- [] Article: "Part I: Idempotence", Embedded Related

- [] Article: "Part II: Immutability", Embedded Related

- [] Article: "Part III: Volatility", Embedded Related

- [] Article: "Part IV: Singletons", Embedded Related

- [] Article: "Part V: State Machines", Embedded Related

- [] Article: "Part VI : Abstraction", Embedded Related

C Keywords

☐ Article: "Keywords to Frequent", Barr Group

☐ Article: "Efficient C Code for 8-bit Microcontrollers", Barr Group

- **volatile**

    - ☐ Video: "Tech Talk: Pro Tips for Using C's Volatile Keyword", YouTube

- **static**

    - ☐ Article: "Scope regions in C and C++", Embedded

- **const**

- **pragma**

    - ☐ Article: "Pragmas", GCC GNU

- **attribute**

    - ☐ Video: "Compiler Attributes", Coursera
    - ☐ Article: "Using GNU C attribute", unixwiz

- **restrict**

- **inline**

- ○ ☐ [Article: "Inline Functions In C", greenend](#)

Watchdog Timer

- ☐ [Article: "Introduction to Watchdog Timers", Embedded](#)

Memory Alignment

- ☐ [Video: "Memory Alignment", Coursera](#)

Pointers

- ☐ [Video: "Pointers", Coursera](#)

Bit Manipulation

- **Bitwise**

  - ○ ☐ [Video: "Switching to C to Program the MSP430 - Bitwise Logic Operations", YouTube](#)

- **Arithmetic**

  - ○ ☐ [Video: "Switching to C to Program the MSP430 - Arithmetic", YouTube](#)

Interrupts

☐ [Article: "Introduction to Microcontrollers - Interrupts", Embedded Related](#)

- ☐ **MSP430 Interrupts**

  - ○ ☐ [Video: "Overview and Basic Concepts", YouTube](#)

  - ○ ☐ [Video: "Interrupts Overview & Port Interrupt Example", YouTube](#)

  - ○ ☐ [Video: "Overview of the Interrupt Vector Table", YouTube](#)

  - ○ ☐ [Video: "The use of the STACK during an IRQ + Nested IRQs", YouTube](#)

  - ○ ☐ [Video: "The Responsibility of the Developer when using IRQs", YouTube](#)

  - ○ ☐ [Video: "The IRQs on the MSP430FR2355 MCU", YouTube](#)

  - ○ ☐ [Video: "Port Interrupts on the MSP430FR2355 MCU - Overview", YouTube](#)

  - ○ ☐ [Video: "Reading from a Switch Using a Port IRQ Program Example", YouTube](#)

  - ○ ☐ [Video: "Changing Edge Sensitivity (PxIES) & Forgetting to Clear a Flag", YouTube](#)

Optimizations

- ☐ [Article: "Optimizing Your Code", Barr Group](#)

Coding Standards

☐ Article: "Embedded C Coding Standards", Barr Group

☐ Video: "Tech Talk: Are Coding Standards & Static Analysis Really That Important?", YouTube

Blog: "Coding Standards", Barr Group

- **MISRA**

  - ☐ Video: "An Introduction to MISRA C - Excerpt from An Introduction to MISRA C:2012 Webinar", YouTube

- **ISO/IEC 90003**

  - ☐ Article: "ISO/IEC/IEEE 90003:2018 Software engineering — Guidelines for the application of ISO 9001:2015 to computer software", ISO

Embedded Software Layers

Peripheral and Hardware Layer

☐ Article: "Peripherals", Barr Group

- **Registers**

  - ☐ Video: "Level Up Your Arduino Code: Registers", YouTube

- **Bit Fields**

  - ☐ Video: "Bit Fields in C. What are they, and how do I use them?", YouTube

- **Memory Map**

  - ☐ Video: "Memory Map and Registers", Coursera

- **Peripherals**

  - ☐ Video: "Exploring Configurable Logic Peripherals on PIC® and AVR® Microcontrollers", YouTube

Hardware Abstraction Layer

☐ Video: "The Nios® II Processor: Hardware Abstraction Layer", YouTube

Textbook: "Reusable Firmware Development: A Practical Approach to APIs, HALs and Drivers", Amazon

- **Register Definition Files**

  ☐ Video: "Register Definition Files", Coursera

- **Memory Access Methods**

- **Board Support Package**

  ☐ Video: "0x1b7 What is a BSP | Board Support Package | Big Picture | Embedded Systems Software Development", YouTube

Application Layer

- **Data Structures and Algorithms**

  - **Queue**

    - **Circular Buffer**

      - ☐ Video: "Circular Buffer | Circular Buffer Implementation in C", YouTube

    - **Semaphore**

      - ☐ Video: "Semaphores", YouTube

      - ☐ Video: "Webinar: Mutexes & Semaphores Demystified", YouTube

    - **Event Handling**

      - ☐ Video: "Embedded Programming Lesson 33: Event-Driven Programming part-1", YouTube

      - ☐ Video: "Embedded Programming Lesson 34: Event-Driven Programming part-2", YouTube

    - **Producer-Consumer**

      - ☐ Video: "Producer Consumer Pattern", YouTube

      - ☐ Video: "Quick explanation: the Bounded-Buffer problem", YouTube

- **Domain Knowledge**

  - **Digital Signal Processing**

    ☐ Video: "Learn Embedded Systems Design on ARM based Microcontrollers 1 of 2", YouTube

    ☐ Video: "Learn DSP on ARM based Microcontrollers 2 of 2", YouTube

    - **FFT**

      - ☐ Video: "Digital Signal Processing (DSP) Tutorial - DSP with the Fast Fourier Transform Algorithm", YouTube

    - **Filters**

      - **IIR**

- - - Video: "IIR Filters - Audio DSP On STM32 with I2S (24 Bit / 96 kHz)", YouTube

    - **FIR**

      - Video: "FIR Filters - Audio DSP On STM32 (24 Bit / 48 kHz)", YouTube

  - **Control Systems**

    - **PID**

      ☐ **Understanding PID Control**

      - Video: "Part 1: What is PID Control?", YouTube
      - Video: "Part 2: Expanding Beyond a Simple Integral", YouTube
      - Video: "Part 3: Expanding Beyond a Simple Derivative", YouTube
      - Video: "Part 4: A PID Tuning Guide", YouTube
      - Video: "Part 5: Three Ways to Build a Model", YouTube
      - Video: "Part 6: Manual and Automatic Tuning Methods", YouTube
      - Video: "Part 7: Important PID Concepts", YouTube

      ☐ **Drone Simulation and Control**

      - Video: "Part 1: Setting Up the Control Problem", YouTube
      - Video: "Part 2: How Do You Get a Drone to Hover?", YouTube
      - Video: "Part 3: How to Build the Flight Code", YouTube
      - Video: "Part 4: How to Build a Model for Simulation", YouTube
      - Video: "Part 5: Tuning the PID controller", YouTube

    - **Solar**

      - Video: "How to implement maximum power point tracking for solar charging", YouTube

  - **Cryptography and Encryption**

Debugging

☐ Article: "Downloading and Debugging", Barr Group

Blog: "Debugging", Barr Group

Static Analysis

- ☐ Video: "Static Code Analysis: Scan All Your Code For Bugs", YouTube

- ☐ Video: "Using PC-Lint for MISRA and static code analysis", YouTube

Dynamic Analysis

Logic Analyzer

- ☐ Video: "EEVblog #44 Part 1 - Logic Analyzer Tutorial", YouTube

- ☐ Video: "EEVblog #44 - Part 2 - Logic Analyzer Tutorial", YouTube

Oscilliscope

- ☐ Video: "How to Debug Embedded Designs with an Oscilloscope", YouTube

- ☐ Video: "How to test Automotive Serial Buses with Oscilloscopes", YouTube

JTAG

- ☐ Video: "", YouTube

SWD

- ☐ Video: "", YouTube

Testing and Quality Management

Phil Koopman Lectures

- ☐ Playlist: "Embedded Software Testing", YouTube

- ☐ Playlist: "Embedded Security, Safety, and Software Quality", YouTube