embOS

Real-Time Operating System

CPU & Compiler specifics for 8051 using IAR

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Manual versions

This manual describes the current software version. If you find an error in the manual or a problem in the software, please inform us and we will try to assist you as soon as possible. Contact us for further information on topics or functions that are not yet documented.

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Software	Revision	Date	By	Description
5.16.1.0	0	220211	TS	New software version.
4.00a	0	140804	TS	Initial version.

About this document

Assumptions

This document assumes that you already have a solid knowledge of the following:

- The software tools used for building your application (assembler, linker, C compiler).
- The C programming language.
- The target processor.
- DOS command line.

If you feel that your knowledge of C is not sufficient, we recommend *The C Programming Language* by Kernighan and Richie (ISBN 0--13--1103628), which describes the standard in C programming and, in newer editions, also covers the ANSI C standard.

How to use this manual

This manual explains all the functions and macros that the product offers. It assumes you have a working knowledge of the C language. Knowledge of assembly programming is not required.

Typographic conventions for syntax

This manual uses the following typographic conventions:

Style	Used for
Body	Body text.
`Keyword`	Text that you enter at the command prompt or that appears on the display (that is system functions, file- or pathnames).
`Parameter`	Parameters in API functions.
`Sample`	Sample code in program examples.
`Sample comment`	Comments in program examples.
Reference	Reference to chapters, sections, tables and figures or other documents.
GUIElement	Buttons, dialog boxes, menu names, menu commands.
Emphasis	Very important sections.

Table of contents

Chapter 1

Using embOS

1.1 Installation

This chapter describes how to start with embOS. You should follow these steps to become familiar with embOS.

embOS is shipped as a zip-file in electronic form.

To install it, proceed as follows:

Extract the zip-file to any folder of your choice, preserving the directory structure of this file. Keep all files in their respective sub directories. Make sure the files are not read only after copying.

Assuming that you are using an IDE to develop your application, no further installation steps are required. You will find many prepared sample start projects, which you should use and modify to write your application. So follow the instructions of section *First Steps* on page 10.

You should do this even if you do not intend to use the IDE for your application development to become familiar with embOS.

If you do not or do not want to work with the IDE, you should: Copy either all or only the library-file that you need to your work-directory. The advantage is that when switching to an updated version of embOS later in a project, you do not affect older projects that use embOS, too. embOS does in no way rely on an IDE, it may be used without the IDE using batch files or a make utility without any problem.

1.2 First Steps

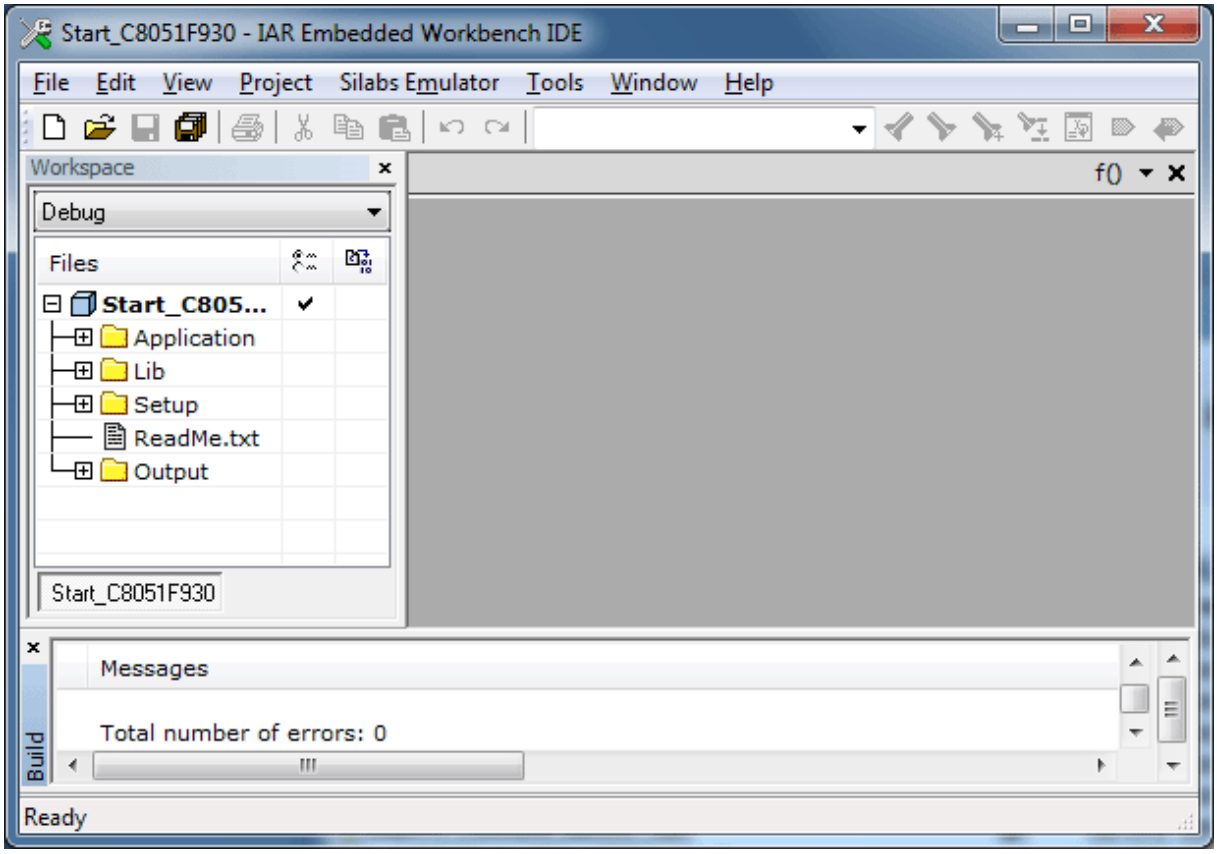
After installation of embOS you can create your first multitasking application. You have received several ready to go sample start workspaces and projects and every other files needed in the subfolder `Start`. It is a good idea to use one of them as a starting point for all of your applications. The subfolder `BoardSupport` contains the workspaces and projects which are located in manufacturer- and CPU-specific subfolders.

To start with, you may use any project from `BoardSupport` subfolder.

To get your new application running, you should proceed as follows:

- Create a work directory for your application, for example `c:\work`.
- Copy the whole folder `Start` which is part of your embOS distribution into your work directory.
- Clear the read-only attribute of all files in the new `Start` folder.
- Open one sample workspace/project in `Start\BoardSupport\<DeviceManufacturer>\<CPU>` with your IDE (for example, by double clicking it).
- Build the project. It should be built without any error or warning messages.

After generating the project of your choice, the screen should look like this:



For additional information you should open the ReadMe.txt file which is part of every specific project. The ReadMe file describes the different configurations of the project and gives additional information about specific hardware settings of the supported eval boards, if required.

1.3 The example application OS_StartLEDBlink.c

The following is a printout of the example application `OS_StartLEDBlink.c`. It is a good starting point for your application. (Note that the file actually shipped with your port of embOS may look slightly different from this one.)

What happens is easy to see:

After initialization of embOS two tasks are created and started. The two tasks are activated and execute until they run into the delay, then suspend for the specified time and continue execution.

```
/*********************************************************************
*                     SEGGER Microcontroller GmbH                    *
*                        The Embedded Experts                        *
**********************************************************************

-------------------------- END-OF-HEADER -----------------------------
File    : OS_StartLEDBlink.c
Purpose : embOS sample program running two simple tasks, each toggling
          a LED of the target hardware (as configured in BSP.c).
*/

#include "RTOS.h"
#include "BSP.h"

static OS_STACKPTR int StackHP[128], StackLP[128];  // Task stacks
static OS_TASK         TCBHP, TCBLP;                // Task control blocks

static void HPTask(void) {
  while (1) {
    BSP_ToggleLED(0);
    OS_TASK_Delay(50);
  }
}

static void LPTask(void) {
  while (1) {
    BSP_ToggleLED(1);
    OS_TASK_Delay(200);
  }
}

/*********************************************************************
*
*       main()
*/
int main(void) {
  OS_Init();    // Initialize embOS
  OS_InitHW();  // Initialize required hardware
  BSP_Init();   // Initialize LED ports
  OS_TASK_CREATE(&TCBHP, "HP Task", 100, HPTask, StackHP);
  OS_TASK_CREATE(&TCBLP, "LP Task",  50, LPTask, StackLP);
  OS_Start();   // Start embOS
  return 0;
}

/************************** End of file ******************************/
```

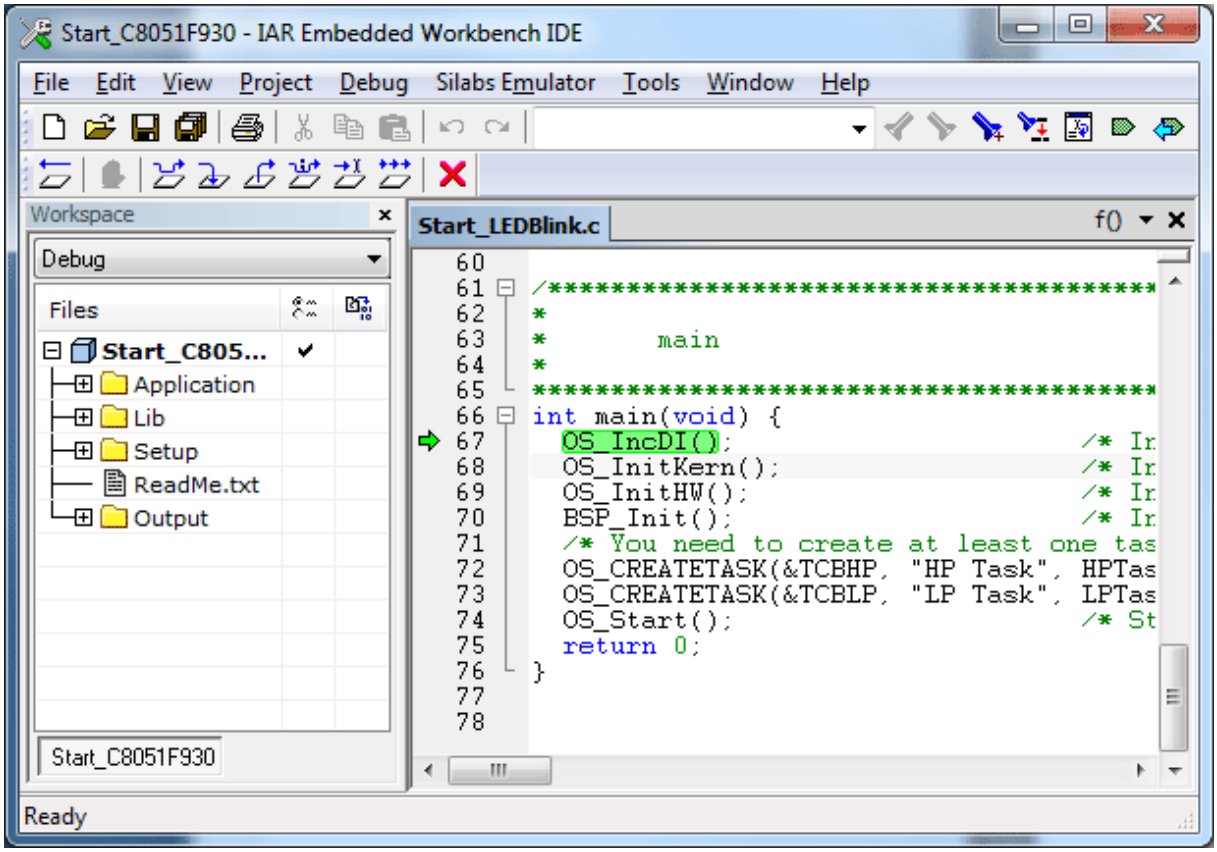

1.4 Stepping through the sample application

When starting the debugger, you will see the `main()` function (see example screenshot below). The `main()` function appears as long as project option `Run to main` is selected, which it is enabled by default. Now you can step through the program.

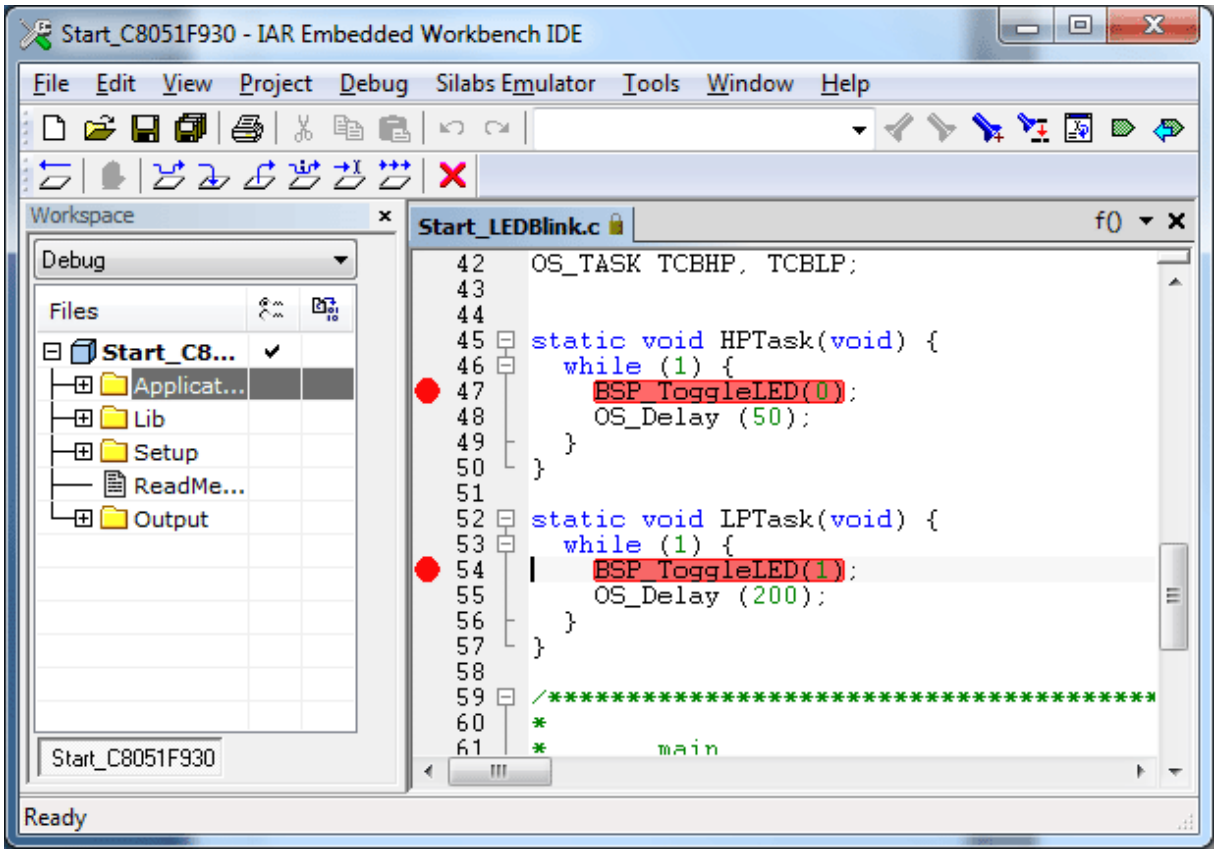
`OS_Init()` is part of the embOS library and written in assembler; you can therefore only step into it in disassembly mode. It initializes the relevant OS variables.

`OS_InitHW()` is part of `RTOSInit.c` and therefore part of your application. Its primary purpose is to initialize the hardware required to generate the system tick interrupt for embOS. Step through it to see what is done.

`OS_Start()` should be the last line in `main()`, because it starts multitasking and does not return.

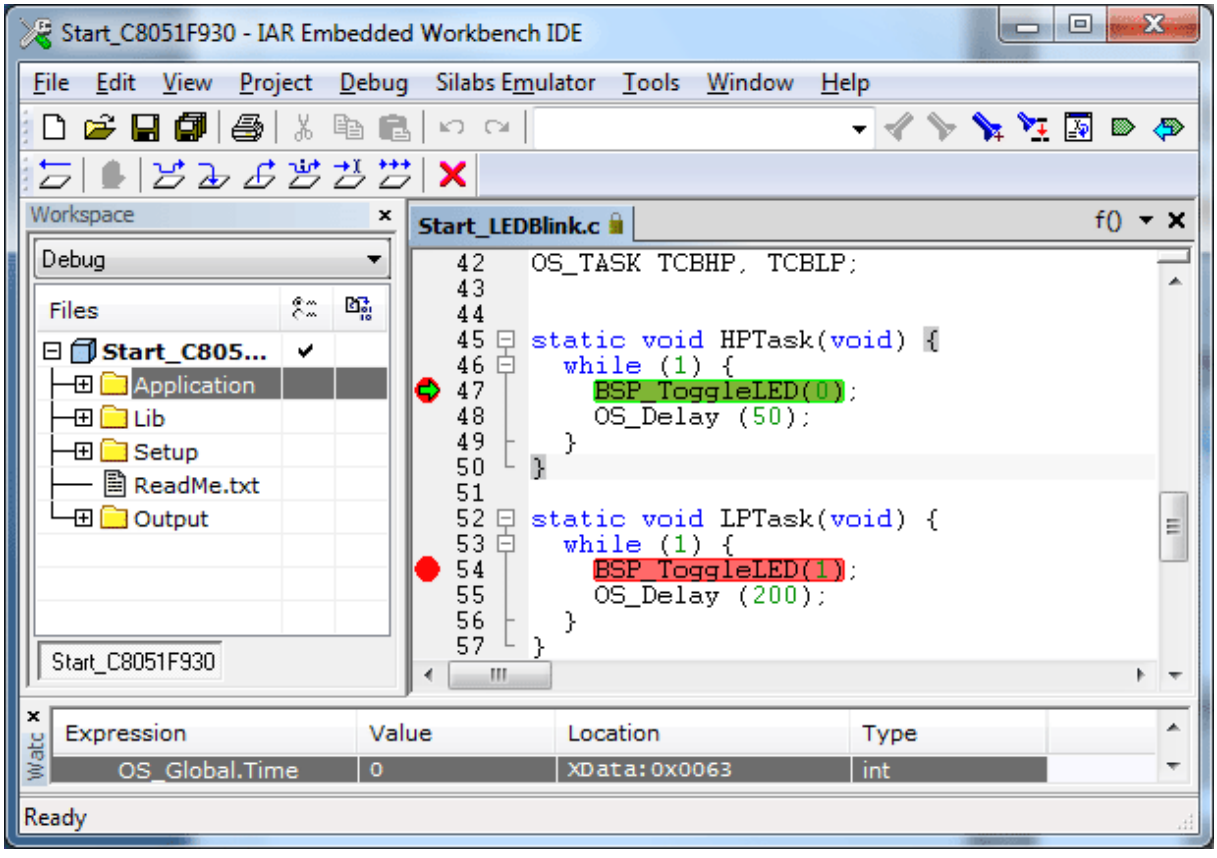


Before you step into `OS_Start()`, you should set two breakpoints in the two tasks as shown below.

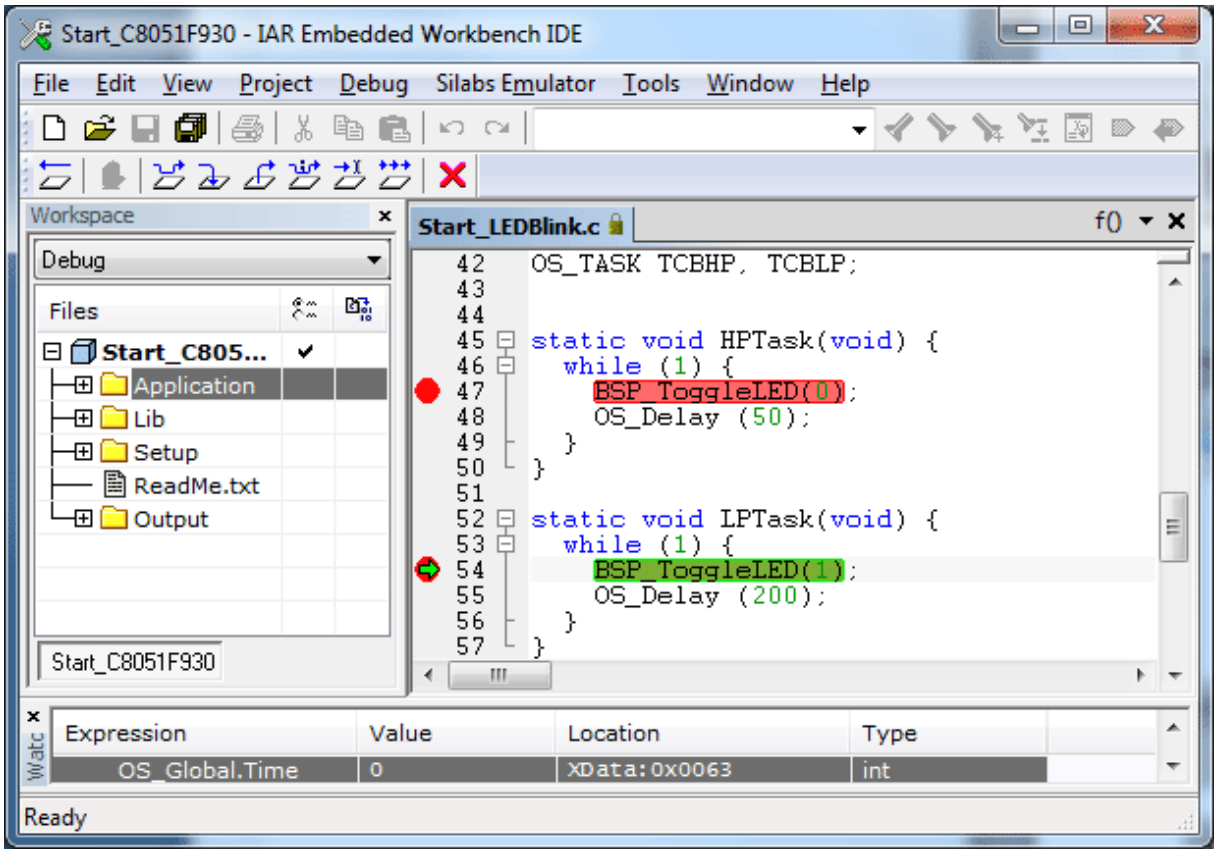


As `OS_Start()` is part of the embOS library, you can step through it in disassembly mode only.

Click `GO`, step over `OS_Start()`, or step into `OS_Start()` in disassembly mode until you reach the highest priority task.

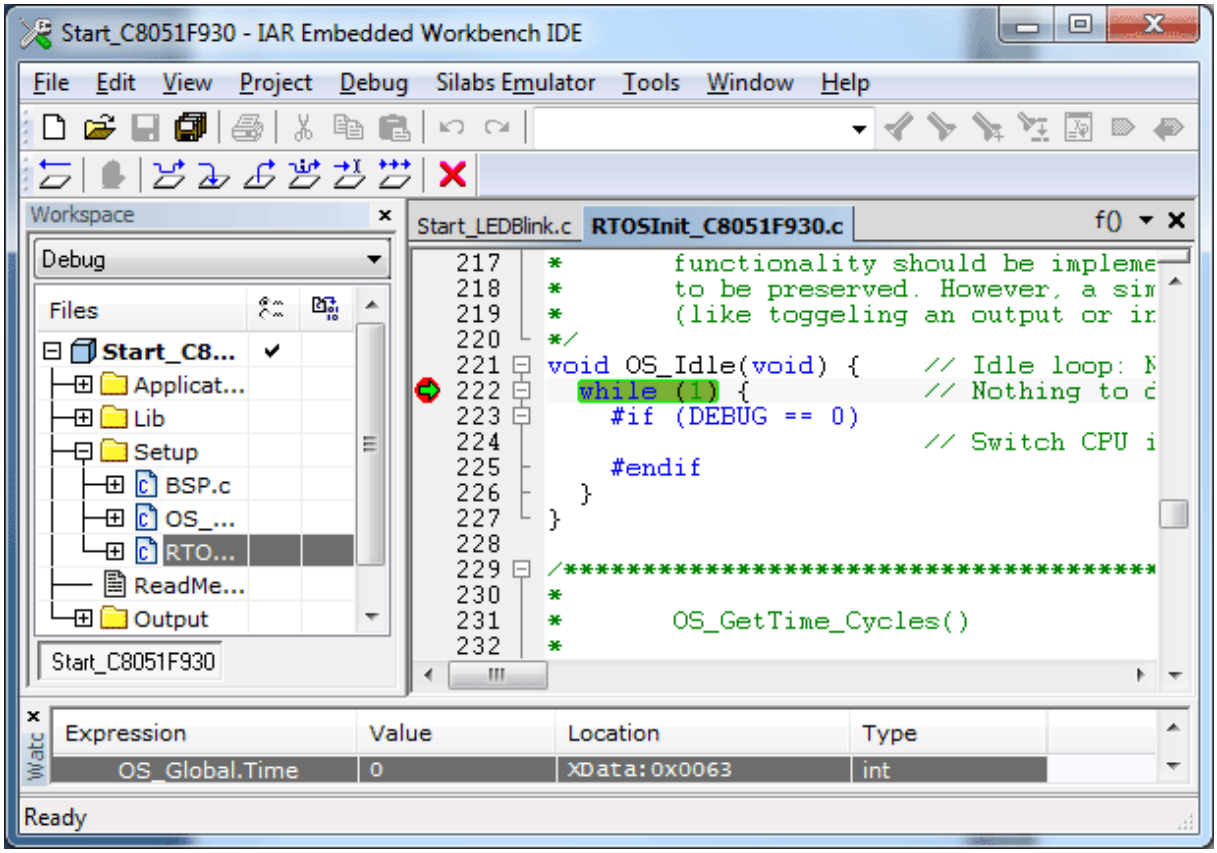


If you continue stepping, you will arrive at the task that has lower priority:



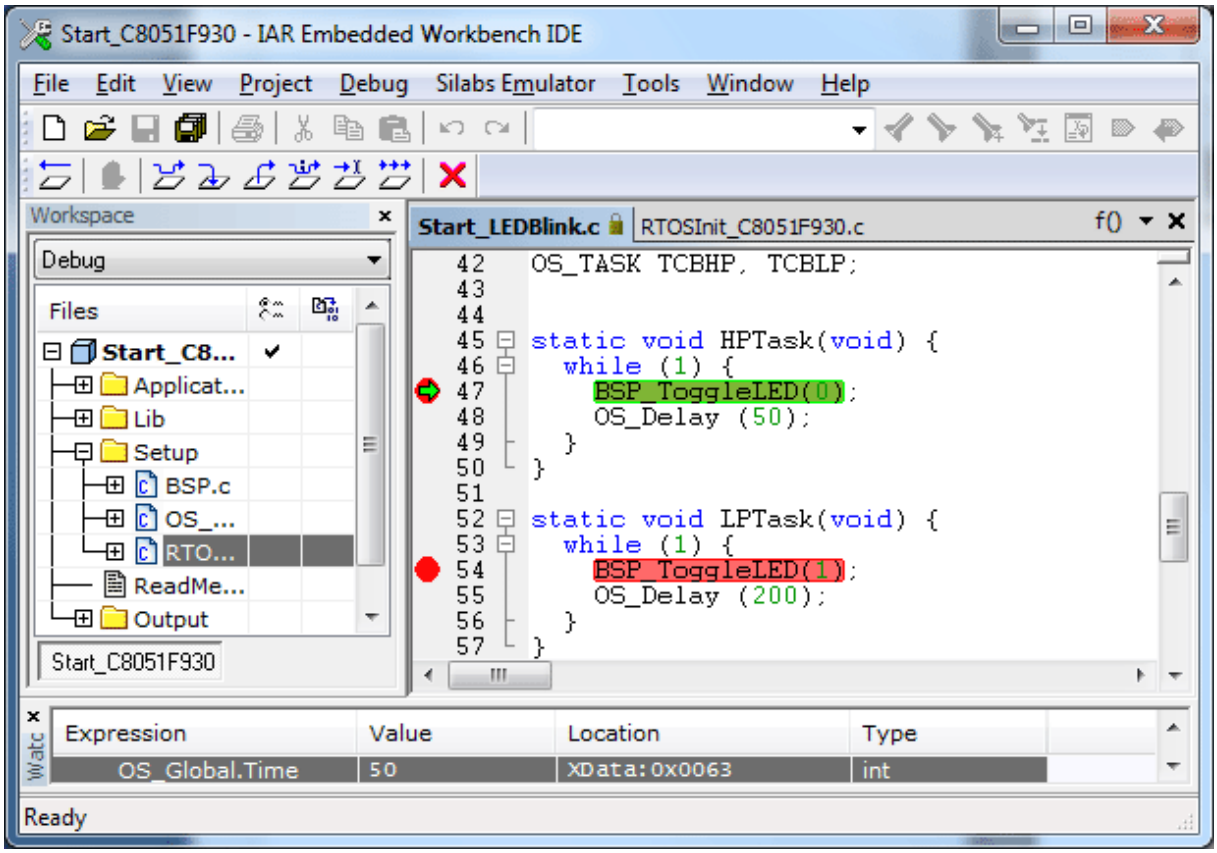
Continue to step through the program, there is no other task ready for execution. embOS will therefore start the idle-loop, which is an endless loop always executed if there is nothing else to do (no task is ready, no interrupt routine or timer executing).

You will arrive there when you step into the `OS_TASK_Delay()` function in disassembly mode. `OS_Idle()` is part of `RTOSInit.c`. You may also set a breakpoint there before stepping over the delay in `LPTask()`.



If you set a breakpoint in one or both of our tasks, you will see that they continue execution after the given delay.

As can be seen by the value of embOS timer variable `OS_Global.Time`, shown in the Watch window, `HPTask()` continues operation after expiration of the delay.



Chapter 2

Build your own application

2.1 Introduction

This chapter provides all information to set up your own embOS project. To build your own application, you should always start with one of the supplied sample workspaces and projects. Therefore, select an embOS workspace as described in chapter *First Steps* on page 10 and modify the project to fit your needs. Using an embOS start project as starting point has the advantage that all necessary files are included and all settings for the project are already done.

2.2 Required files for an embOS

To build an application using embOS, the following files from your embOS distribution are required and have to be included in your project:

- **RTOS.h** from the directory `.\Start\Inc`. This header file declares all embOS API functions and data types and has to be included in any source file using embOS functions.
- **RTOSInit*.c** from one target specific `.\Start\BoardSupport\<Manufacturer>\<MCU>` subfolder. It contains hardware-dependent initialization code for embOS. It initializes the system timer interrupt but can also initialize or set up the interrupt controller, clocks and PLLs, the memory protection unit and its translation table, caches and so on.
- **OS_Error.c** from one target specific subfolder `.\Start\BoardSupport\<Manufacturer>\<MCU>`. The error handler is used only if a debug library is used in your project.
- One **embOS library** from the subfolder `.\Start\Lib`.
- Additional CPU and compiler specific files may be required according to CPU.

When you decide to write your own startup code or use a low level `init()` function, ensure that non-initialized variables are initialized with zero, according to C standard. This is required for some embOS internal variables. Your `main()` function has to initialize embOS by calling `OS_Init()` and `OS_InitHW()` prior to any other embOS functions that are called.

2.3 Change library mode

For your application you might want to choose another library. For debugging and program development you should always use an embOS debug library. For your final application you may wish to use an embOS release library or a stack check library.

Therefore you have to select or replace the embOS library in your project or target:

- If your selected library is already available in your project, just select the appropriate project configuration.
- To add a library, you may add the library to the existing Lib group. Exclude all other libraries from your build, delete unused libraries or remove them from the configuration.
- Check and set the appropriate `OS_LIBMODE_*` define as preprocessor option and/or modify the `OS_Config.h` file accordingly.

2.4 Select another CPU

embOS contains CPU-specific code for various CPUs. Manufacturer- and CPU-specific sample start workspaces and projects are located in the subfolders of the `.\Start\BoardSupport` directory. To select a CPU which is already supported, just select the appropriate workspace from a CPU-specific folder.

If your CPU is currently not supported, examine all `RTOSInit.c` files in the CPU-specific subfolders and select one which almost fits your CPU. You may have to modify `OS_InitHW()`, the interrupt service routines for the embOS system tick timer and the low level initialization.

Chapter 3

Libraries

This chapter includes CPU-specific information such as CPU-modes and available libraries.

3.1 Naming conventions for prebuilt libraries

embOS is shipped with different pre-built libraries with different combinations of the following features:

- Library mode - `LibMode`

The libraries are named as follows:

`os8051_<LibMode>.r51`

Parameter	Meaning	Values
`LibMode`	Specifies the library mode.	XR: Extreme Release R: Release S: Stack check SP: Stack check + profiling D: Debug DP: Debug + profiling DT: Debug + profiling + trace

Example

`os8051_DP.r51` is the library for a project using a 8051 core with debug and profiling support.

Chapter 4

CPU and compiler specifics

4.1 CPU modes

embOS for 8051 supports only the Near code and Large data model with XDATA stack and reentrant calling convention.

4.2 Standard system libraries

embOS for 8051 and IAR may be used with IAR standard libraries.

4.3 OS_Stop()

`OS_Stop()` is not implemented for embOS 8051 IAR and must not be called from the application.

4.4 Extended task context

embOS 8051 IAR does not support an extended task context.

Chapter 5

Stacks

5.1 Task stack

Each task uses its individual stack. The stack pointer is initialized and set every time a task is activated by the scheduler. The stack-size required for a task is the sum of the stack-size of all routines, plus a basic stack size, plus size used by exceptions.

The basic stack size is the size of memory required to store the registers of the CPU plus the stack size required by calling embOS-routines.

The 8051 uses an 8-bit stack pointer which can address the 256 bytes IDATA memory. The IAR compiler uses an additional software stack pointer which points to the XDATA memory. While the IDATA stack is still used for e.g. a function return address the IAR compiler switches to the software stack for most of the stack handling. The fixed IDATA task stack size is 128 bytes which is sufficient for most of the applications.

The software stack pointer is initialized by embOS to the end of the task stack and grows to lower addresses. The hardware stack pointer grows to higher addresses. With each task switch the used IDATA task stack is saved to the task stack in XDATA and restored with the next task switch. Thus the task stack is divided into two parts, one part for the saved hardware stack in IDATA and the other part for the software stack in XDATA. We recommend at least 256 bytes task stack as a start.

5.2 System stack

The minimum system stack size required by embOS is about 20 bytes (stack check & profiling build). However, since the system stack is also used by the application before the start of multitasking (the call to `OS_Start()`), the actual stack requirements depend on the application. We recommend a minimum stack size of 80 bytes for the system stack.

5.3 Interrupt stack

The 8051 core has no separate interrupt stack pointer. If an interrupt occurs, the 8051 core saves the return address on the current stack which could be a task stack or system stack.

5.4 Stack check

embOS 8051 IAR does not support stack check due to the two used stacks in IDATA and XDATA.

Chapter 6

Interrupts

6.1 What happens when an interrupt occurs?

- The CPU-core receives an interrupt request form the interrupt controller.
- As soon as the interrupts are enabled, the interrupt is accepted and executed.
- The CPU pushes the return address onto the current stack.
- The CPU jumps to the vector address.
- The interrupt handler is processed.
- The interrupt handler ends with a return from interrupt instruction
- The CPU returns to the address from the stack and continues the interrupted function.

6.2 Defining interrupt handlers in C

Interrupt handler for 8051 cores are written as normal C-functions which do not take parameters and do not return any value. Interrupt handler which call an embOS function need a prologue and epilogue function as described in the generic manual and in the examples below. Interrupt handler needs the `#pragma` statement with the interrupt vector number and the `__interrupt` keyword.

Example

Simple interrupt routine:

```
#pragma vector = 0x2B
__interrupt void SysTick_Handler(void);
__interrupt void SysTick_Handler(void) {
  TMR2CN &= ~TMR2_TF2H_MASK;
  OS_INT_EnterNestable();
  OS_TICK_Handle();
  OS_INT_LeaveNestable();
}
```

6.3 Zero latency interrupts

6.3.1 Zero latency interrupts with 8051

The 8051 CPU does not support execution priority thus embOS has to disable all interrupts for internal operations. Therefore zero latency interrupts are not supported.

6.4 Interrupt priorities

The 8051 CPU has two interrupt priorities, low and high. Each interrupt can be initialized with low or high priority.

> **Note**
>
> Interrupt routines with high priority must not call any embOS API functions.

6.5 Interrupt nesting

The 8051 CPU uses a priority controlled interrupt scheduling which allows nesting of interrupts per default. Any interrupt with high interrupt priority may interrupt an interrupt handler running on the low interrupt priority.

Chapter 7

Technical data

7.1 Resource Usage

The memory requirements of embOS (RAM and ROM) differs depending on the used features, CPU, compiler, and library model. The following values are measured using embOS library mode `OS_LIBMODE_XR`.

Module	Memory type	Memory requirements
embOS kernel	ROM	~1700 bytes
embOS kernel	RAM	~86 bytes
Task control block	RAM	15 bytes
Software timer	RAM	9 bytes
Task event	RAM	0 bytes
Event object	RAM	5 bytes
Mutex	RAM	7 bytes
Semaphore	RAM	4 bytes
RWLocks	RAM	13 bytes
Mailbox	RAM	13 bytes
Queue	RAM	15 bytes
Watchdog	RAM	6 bytes
Fixed Block Size Memory Pool	RAM	16 bytes

