TB3169

Enabling Various RTOS Support with MPLAB® Harmony

INTRODUCTION

In embedded applications, there are situations where the application needs to stop its current activity and start another task or respond to an external event. In an environment without an operating system, the only way to achieve this is by using interrupts. Interrupts allow application code preemption.

In applications that are developed using the MPLAB® Harmony software framework, the various layers like application, middleware, and driver run in a cooperative manner by breaking down each task into small units of execution. However, the events are processed only when the program gets the chance to run a task. As a result, the cycle time to process the events may be non-deterministic and may vary as functions are added, removed, or changed.

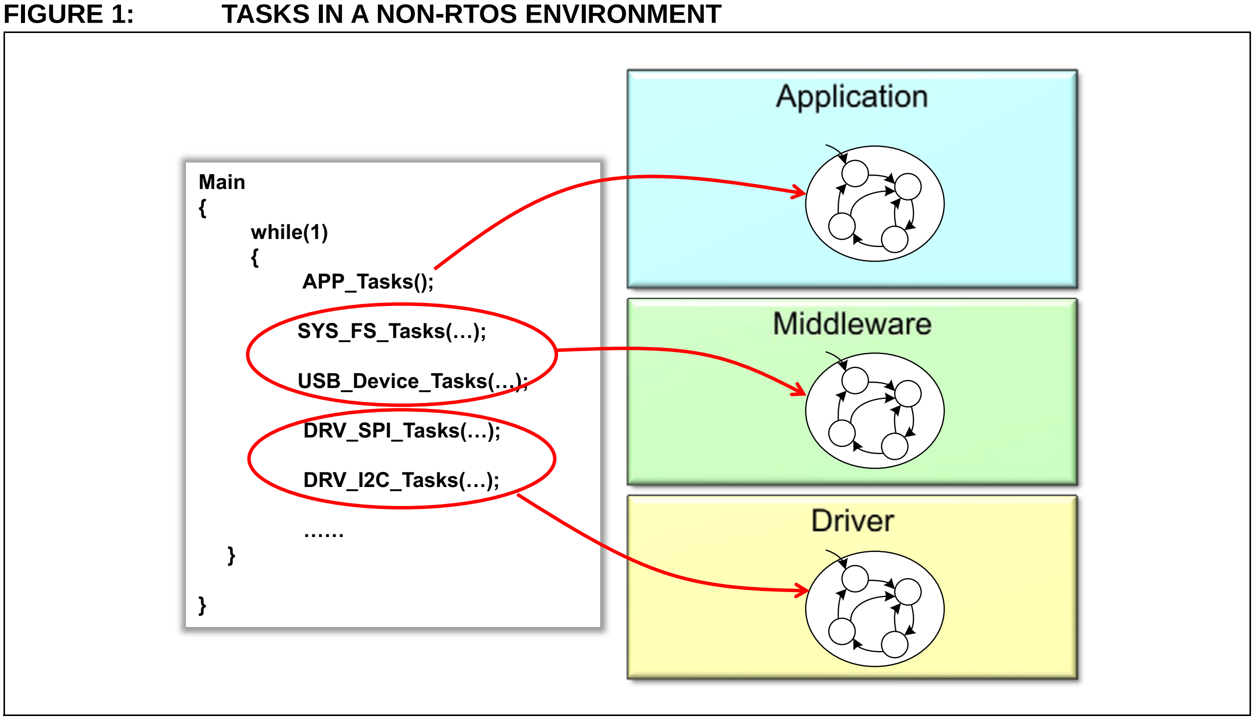
Real-Time Operating Systems (RTOS) can preempt a task and allow other high-priority tasks to execute. In addition, the RTOS scheduler ensures that the tasks waiting for the resources or events do not waste the CPU time. Such tasks move to a blocked state, and the tasks that are ready to run get the CPU time. This results in a more effective utilization of the CPU bandwidth.

CONCEPT

In an RTOS environment, instead of running all the tasks from a big super loop, each individual task can be run in a dedicated loop. This allows the individual task to be assigned a priority, and therefore, provides for a better responsiveness by assigning a high priority to tasks that are time-critical (hard real-time) in nature. Figure 1 shows how tasks in a MPLAB Harmony-based application are run from a super loop in a non-RTOS environment.

Figure 2 shows how each task can be run in an individual thread when the MPLAB Harmony application is configured to run in a RTOS environment. Usually, the driver task routines may still be run from an interrupt context. Interrupts usually support the best real-time response latency and hardware usually provides mechanisms for setting interrupt priorities.

FIGURE 1: TASKS IN A NON-RTOS ENVIRONMENT



RTOS SUPPORT IN MPLAB HARMONY

Microchip offers solutions from industry-leading RTOS specialist vendors. These solutions are compatible with the MPLAB Harmony framework and integrate with MPLAB Harmony Configurator (MHC).

MPLAB Harmony supports the following RTOS options. In addition, support for other RTOS (even custom developed ones) can be easily added.

- FreeRTOS™
- OPENRTOS®
- SEGGER embOS®
- Micriµm® µC/OS-II™
- Micriµm® µC/OS-III™
- Express Logic ThreadX

MHC allows for enabling and configuration of each individual RTOS. Figure 3 shows the selection of RTOS in MHC and the configuration of various parameters of the selected RTOS. Once a RTOS is selected and configured, the application task, the driver tasks running in polled mode, middleware libraries, and system tasks are automatically configured by MHC to run with the selected RTOS. These configuration parameters include the stack size for each thread, priority of the thread, and the task delay as shown in Figure 4. Setting the task delay allows a thread to be put into a blocked state, thereby allowing other threads in the system to run. Users can modify these parameters using MHC.

Note:	For FreeRTOS, details of the RTOS configuration options can be located at: http://www.freertos.org/a00110.html Similarly, the details of the configuration options for other RTOS can be found in the respective RTOS documentation.

FIGURE 2: TASKS IN A RTOS ENVIRONMENT

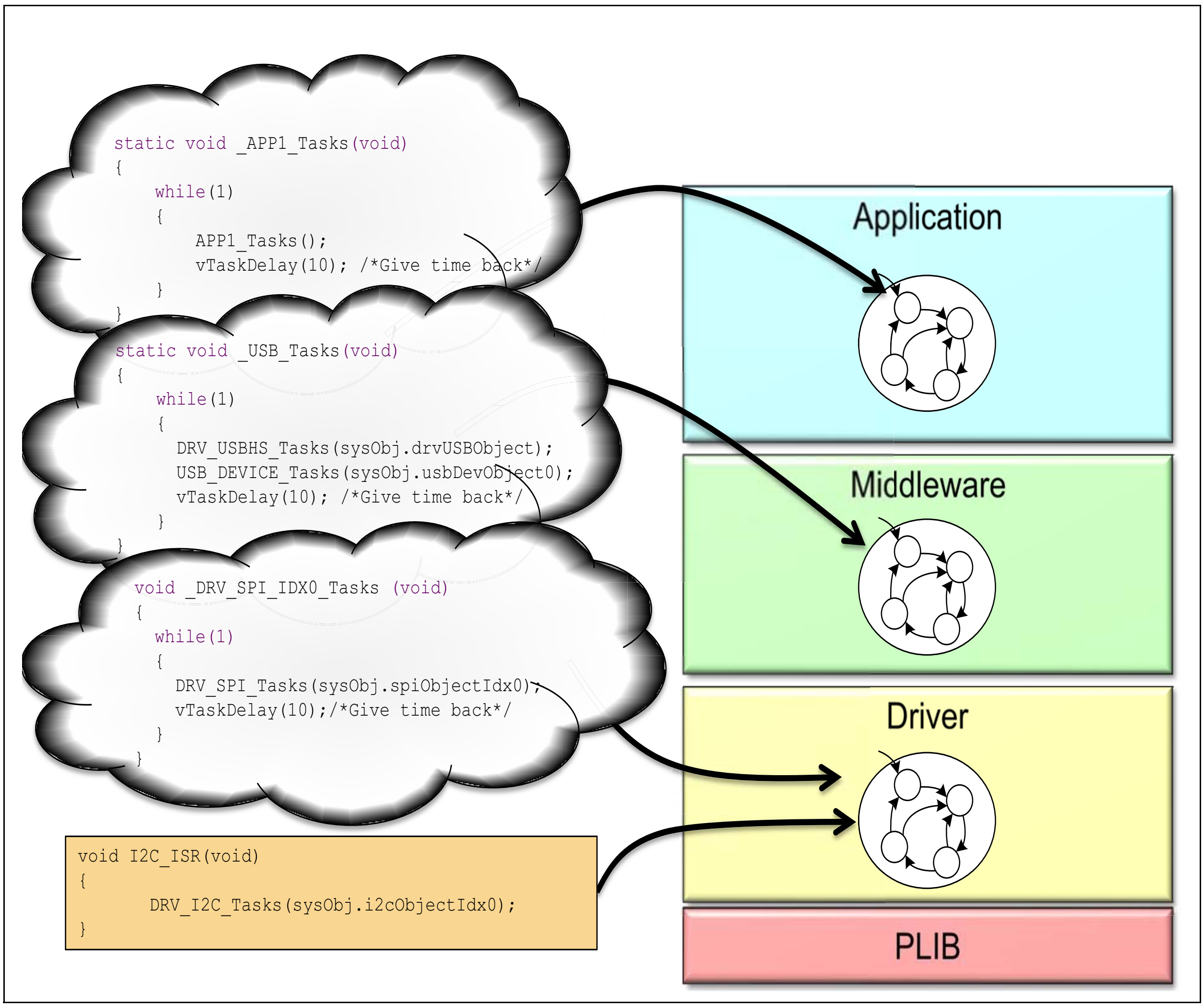


FIGURE 3: ENABLE AND CONFIGURE RTOS IN MHC

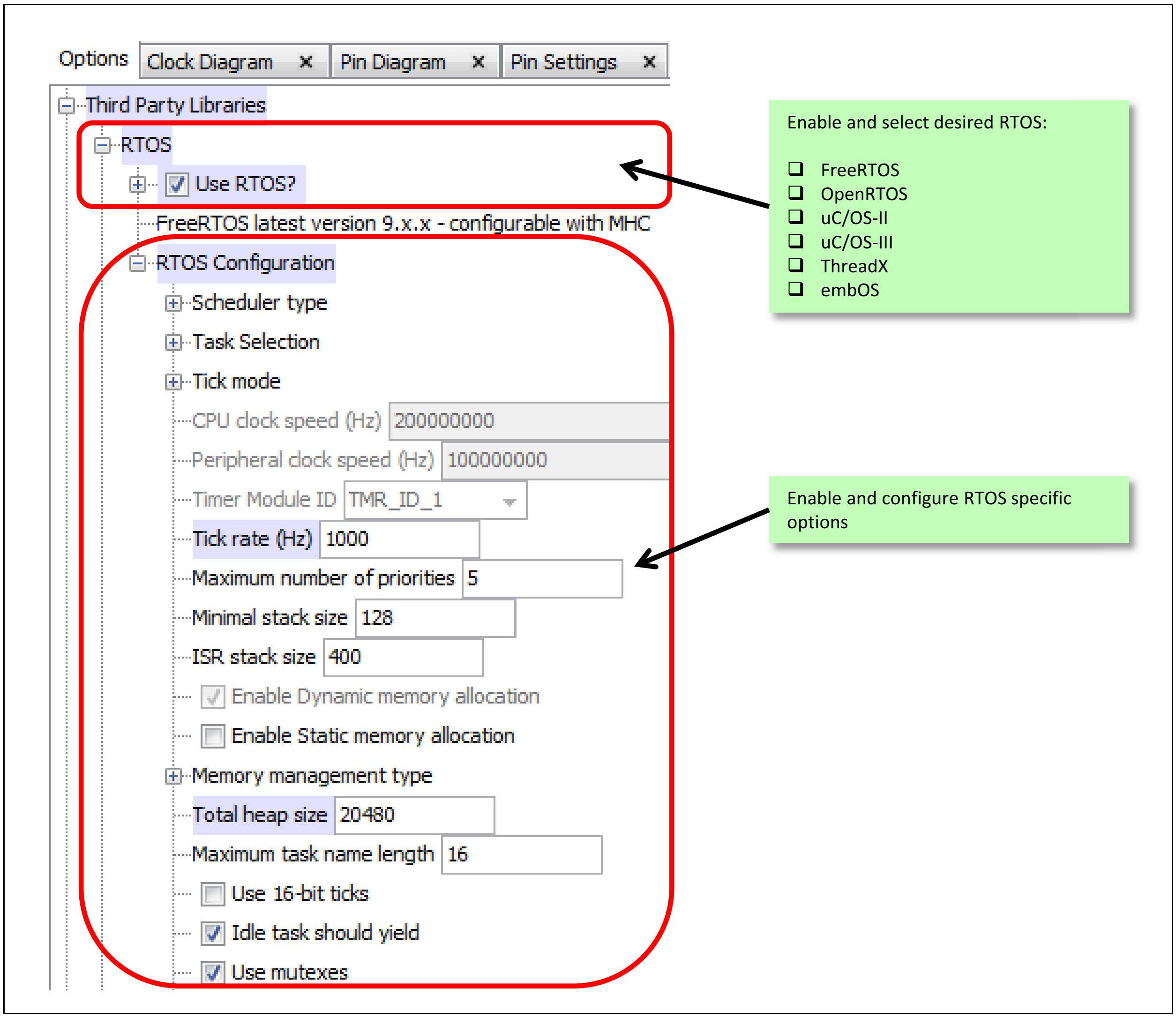
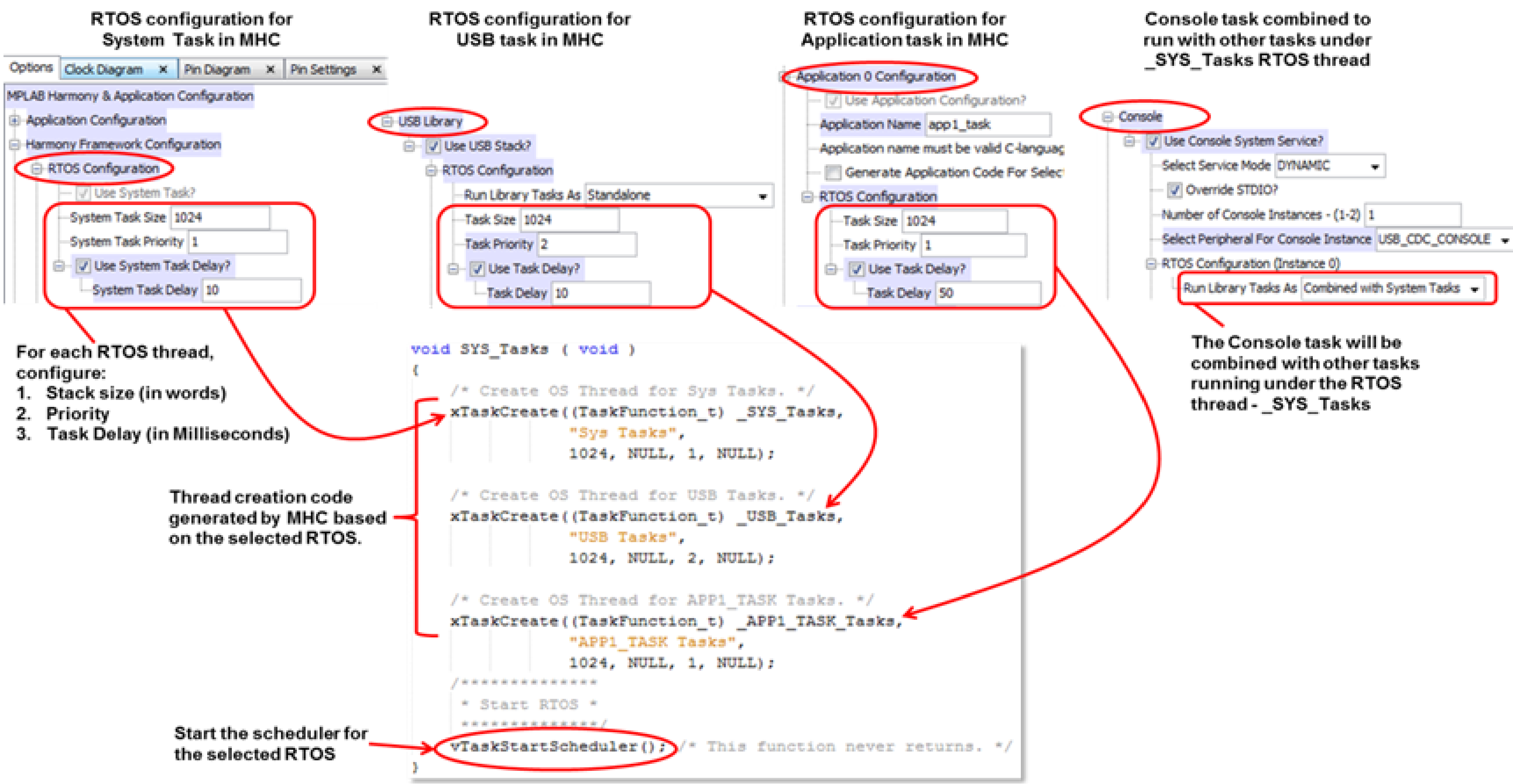


FIGURE 4: FreeRTOS CONFIGURATION EXAMPLE FOR THE MPLAB HARMONY LIBRARIES AND APPLICATION TASKS



MHC allows combining MPLAB Harmony library tasks under the common RTOS thread (_SYS_Tasks) that runs the MPLAB Harmony System modules. Figure 4 shows the MPLAB Harmony Console System Service task combined to run under the common RTOS thread. When MHC generates the code, the MPLAB Harmony System task (SYS_Tasks) routine contains the RTOS specific thread creation code. The System task routine then calls the RTOS scheduler, thereafter all RTOS threads will be managed by the scheduler and the SYS_Tasks function will not return. MHC also generates the individual daemon threads that will run the MPLAB Harmony libraries and the application tasks as shown in Figure 5.

The application remains unchanged, regardless of whether the MPLAB Harmony libraries are configured to work with or without RTOS. The modular design of the MPLAB Harmony libraries ensures that the interface provided by these libraries remains same, regardless of whether the library module is working in an RTOS or non-RTOS environment. Also, the MPLAB Harmony libraries are thread safe as the shared resources are protected against asynchronous access by multiple contesting threads or interrupts.

FIGURE 5: INDIVIDUAL RTOS THREADS CREATED BY MHC THAT RUN THE MPLAB HARMONY LIBRARY AND APPLICATION TASKS

Thread 1 – System Task

```
static void _SYS_Tasks ( void)
{
    while(1)
    {
        /* Maintain system services */
        SYS_CONSOLE_Tasks(sysObj.sysConsole0);

        /* Task Delay */
        vTaskDelay(10 / portTICK_PERIOD_MS);
    }
}
```

Thread 2 – USB Task

```
void _USB_Tasks(void)
{
    while(1)
    {
        /* USBHS Driver Task Routine */
        DRV_USBHS_Tasks(sysObj.drvUSBObject);

        /* USB Device layer tasks routine */
        USB_DEVICE_Tasks(sysObj.usbDevObject0);

        vTaskDelay(10 / portTICK_PERIOD_MS);
    }
}
```

Thread 3 – App1 Task

```
static void _APP1_TASK_Tasks(void)
{
    while(1)
    {
        APP1_TASK_Tasks();
        vTaskDelay(50 / portTICK_PERIOD_MS);
    }
}
```

Tip1: FreeRTOS

For FreeRTOS the Timer1 peripheral is used for generating the kernel ticks. If the Timer1 is already in use by another MPLAB Harmony module, MHC will indicate an error when the RTOS is enabled. To solve this error, the user must configure the MPLAB Harmony module to use a timer peripheral other than Timer1.

Tip2: Combining Library Tasks Under a Common RTOS Thread

Running each library from an individual thread allows the user to better prioritize the tasks of different libraries. However, each thread takes resources and has the task-switching overhead, using CPU bandwidth. Therefore, it often makes sense to combine several simple libraries into a common thread while leaving major libraries, such as USB, TCP/IP, etc., in their own thread.

Tip3: Task Delay

It is not mandatory to configure the Task Delay parameter for the RTOS thread. The Task Delay is only needed to yield the CPU to another thread. If the RTOS thread is designed so that it does not wait on the resources or events, and always uses the resource sharing and inter-task communication methods provided by the RTOS, such as semaphores, mutex, queues etc., the thread will be put in a blocked state until such resources or events are available. This then enables the scheduler to run other threads that are ready to run, and hence does not require using Task Delay to explicitly yield the CPU to other threads in the system.

Tip4: Stack Size

Determining the stack size required by a RTOS thread is important to ensure system stability. However, it is not easy to determine the stack requirements of a RTOS thread. This depends on several factors, such as the number of local variables used, number of nested function calls, space required to save the thread context, and stack required by the nested interrupts if a dedicated interrupt stack is not used.

Some RTOS-specific tools provide several ways to detect stack overflow at run-time or determine the worst case stack used by the individual threads. Therefore, it is generally a good practice to allocate a fairly large stack for each thread in the beginning and then adjust the stack size based on the stack usage analysis.

OTHER RELEVANT RESOURCES

For additional information on RTOS and the MPLAB Harmony Integrated Software Framework, download the MPLAB Harmony framework from the Microchip Website:

http://www.microchip.com/mplab/mplab-harmony

Examples

Refer to the following location in your installation of MPLAB Harmony for examples:

`<install-dir>/apps/rtos`

RTOS Support

MPLAB HARMONY INSTALLATION:

`<install-dir>/doc/help_harmony`

MICROCHIP WIKI:

http://microchipdeveloper.com/harmony:overview-rtos

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