### Document Revision History

<table>
<thead>
<tr>
<th>Revision</th>
<th>Date</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>7 March 2016</td>
<td>Initial release</td>
</tr>
<tr>
<td>1.1</td>
<td>2 May 2016</td>
<td>Refined the logging examples with the SDK.</td>
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<td>Added the log setting commands.</td>
</tr>
<tr>
<td>1.3</td>
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<td>Added the exception handler section.</td>
</tr>
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1. Introduction

MediaTek LinkIt™ development platform for RTOS provides comprehensive support to develop and connect Wearables and IoT applications and devices. System Log facilitates debugging during software development and provides a convenient logging system that supports log filtering and multitasking. Log filtering allows the developers to focus on the specific parts of the logs. Multitasking support ensures the logging is properly managed when multiple tasks call the log API, simultaneously. More details about the System Log API usage, can be found in the header file at `<sdk_root>/kernel/service/inc/syslog.h`.

1.1. System Log architecture

The System Log architecture is shown in Figure 1. The target prints logs using the UART interface. The logs are then displayed on the host side by calling a terminal program such as TeraTerm and Putty. Installing and setting up TeraTerm is described in "Terminal application setup" and "Serial port settings" sections of the “LinkIt for RTOS Get Started Guide” in `<sdk_root>/doc` folder. The target side of Figure 1 is detailed in section 1.4, “Multitasking support”. The host side UART configuration is described in section 3, “Host UART Configuration”.

![Figure 1. System Log architecture](image)

1.2. Log filtering

The logs are grouped by modules. Each module is associated with a log control block to specify whether the log messages within that module will be printed or not. The log control block contains the current log level setting for each module. The caller of the log API specifies the log level, the module and the log message. The System Log then performs filtering based on the log level and the current settings in the module’s log control block. There are three configurable log levels: INFO, WARNING and ERROR ordered by ascending log level. The log message is
printed only if the log level of the current log message is greater than or equal to the log level specified in the log control block of the module. A common module is defined in syslog.c for the type of logs not assigned to any particular module. Users can update the log setting of each module dynamically through the AT commands for LinkIt 2523 HDK or through the CLI commands for LinkIt 7687 HDK. The update takes effect immediately after the commands are issued and log configuration settings are stored in the NVDM.

1.3. Log setting commands

You can create a log module with the function `log_create_module()` (see section 2.1.4, "log_create_module"). The system log is enabled by default with the debug level specified in the macro as an input to the function `log_create_module()`.

The log settings are stored in the NVDM. Once the system reboots, the log settings read from the NVDM override the default settings in the image. If there are no log settings in the NVDM, the default log settings in the image are written to the NVDM. The log settings can be updated through AT commands or CLI commands then the updated settings are stored in the NVDM.

The log control blocks are defined in separate modules. For the convenience of log filtering routine implementation, aggregate the log control blocks, see section 1.2, "Log filtering", for all modules of a project into a table and then apply the AT and CLI commands. More details can be found in sections 2.1.1, "log_init()", 2.1.2, "LOG_CONTROL_BLOCK_DECLARE" and 2.1.3, "LOG_CONTROL_BLOCK_SYMBOL".

An example description to provide the log setting commands is shown below.

1) Open the main source file of the reference project from `<sdk_root>/project/mt2523_hdk/iot_sdk_demo/src/main.c`.

2) Identify the LOG_CONTROL_BLOCK_DECLARE(module) which declares the external reference to the log control block of the given module.

```
LOG_CONTROL_BLOCK_DECLARE(atci);
#ifdef MTK_BT_AT_COMMAND_ENABLE
LOG_CONTROL_BLOCK_DECLARE(atci_bt);
#endif
LOG_CONTROL_BLOCK_DECLARE(atci_charger);
LOG_CONTROL_BLOCK_DECLARE(atci_ctp);
LOG_CONTROL_BLOCK_DECLARE(atci_keypad);
LOG_CONTROL_BLOCK_DECLARE(atci_reg);
LOG_CONTROL_BLOCK_DECLARE(atcmd);
LOG_CONTROL_BLOCK_DECLARE(BLE_MESSAGE);
LOG_CONTROL_BLOCK_DECLARE(BLE_STATIC_CB);
LOG_CONTROL_BLOCK_DECLARE(bt);
LOG_CONTROL_BLOCK_DECLARE(bt_audio);
LOG_CONTROL_BLOCK_DECLARE(bt_sink);
LOG_CONTROL_BLOCK_DECLARE(bt_spp);
LOG_CONTROL_BLOCK_DECLARE(common);
LOG_CONTROL_BLOCK_DECLARE(GNSS_TAG);
```
3) The table `syslog_control_blocks[]` is a reference to the log control block of each module.

```c
log_control_block_t *syslog_control_blocks[] = {
    &LOG_CONTROL_BLOCK_SYMBOL(atci),
    #ifdef MTK_BT_AT_COMMAND_ENABLE
    &LOG_CONTROL_BLOCK_SYMBOL(atci_bt),
    #endif
    &LOG_CONTROL_BLOCK_SYMBOL(atci_charger),
    &LOG_CONTROL_BLOCK_SYMBOL(atci_ctp),
    &LOG_CONTROL_BLOCK_SYMBOL(atci_keypad),
    &LOG_CONTROL_BLOCK_SYMBOL(atci_reg),
    &LOG_CONTROL_BLOCK_SYMBOL(atcmd),
    &LOG_CONTROL_BLOCK_SYMBOL(BLE_MESSAGE),
    &LOG_CONTROL_BLOCK_SYMBOL(BLE_STATIC_CB),
    &LOG_CONTROL_BLOCK_SYMBOL(bt),
    &LOG_CONTROL_BLOCK_SYMBOL(bt_audio),
    &LOG_CONTROL_BLOCK_SYMBOL(bt_sink),
    &LOG_CONTROL_BLOCK_SYMBOL(bt_spp),
    &LOG_CONTROL_BLOCK_SYMBOL(common),
    &LOG_CONTROL_BLOCK_SYMBOL(GNSS_TAG),
    &LOG_CONTROL_BLOCK_SYMBOL(GRAPHIC_TAG),
    &LOG_CONTROL_BLOCK_SYMBOL(hal),
    #ifdef MTK_SMART_BATTERY_ENABLE
    &LOG_CONTROL_BLOCK_SYMBOL(bmt),
    #endif
};
```
4) The user-defined callback functions `syslog_config_save()` and `syslog_config_load()` save and load the log configuration settings of the system.

```c
static void syslog_config_save(const syslog_config_t *config)
{
    nvdm_status_t status;
    char *syslog_filter_buf;

    syslog_filter_buf = (char*)pvPortMalloc(SYSLOG_FILTER_LEN);
    configASSERT(syslog_filter_buf != NULL);
    syslog_convert_filter_val2str((const log_control_block_t **)config->filters, syslog_filter_buf);
    status = nvdm_write_data_item("common",
        "syslog_filters",
        NVDM_DATA_ITEM_TYPE_STRING,
        (const uint8_t *)syslog_filter_buf,
        strlen(syslog_filter_buf));
    vPortFree(syslog_filter_buf);
    LOG_I(common, "syslog config save, status=%d", status);
}

static uint32_t syslog_config_load(syslog_config_t *config)
{
    uint32_t sz = SYSLOG_FILTER_LEN;
    char *syslog_filter_buf;

    syslog_filter_buf = (char*)pvPortMalloc(SYSLOG_FILTER_LEN);
    configASSERT(syslog_filter_buf != NULL);
    if (nvdm_read_data_item("common", "syslog_filters", (uint8_t*)syslog_filter_buf, &sz) == NVDM_STATUS_OK) {
        syslog_convert_filter_str2val(config->filters, syslog_filter_buf);
    } else {
        /* populate the syslog nvdm with the image setting */
        syslog_config_save(config);
    }
```
vPortFree(syslog_filter_buf);
return 0;
}

5) The log configuration settings are stored in NVDM. Call the function nvdm_init() before calling the function log_init(), syslog_config_save(), syslog_config_load() and syslog_control_blocks[] are the input parameters for the log_init() function.

```c
int main(void)
{
    /* SystemClock Config */
    SystemClock_Config();
    SystemCoreClockUpdate();

    /* init UART earlier */
    log_uart_init(HAL_UART_0);

    /* Configure the hardware ready to run the test. */
    prvSetupHardware();
    ...

#ifndef NVDM_DEMO
    nvdm_init();
#endif
#ifndef MTK_PORT_SERVICE_ENABLE
    syslog_port_service_init();
#endif
    log_init(syslog_config_save, syslog_config_load, syslog_control_blocks);
    ...
}
```

### 1.3.1. AT Commands

The AT commands are applicable to LinkIt 2523 HDK only, as shown in Table 1.

<table>
<thead>
<tr>
<th>Description</th>
<th>Command</th>
</tr>
</thead>
<tbody>
<tr>
<td>Query for the usage</td>
<td>AT+SYSLOG=?</td>
</tr>
</tbody>
</table>

**Table 1. AT commands for LinkIt 2523 HDK**
### AT Command example

In this example, the common and HAL log modules are presented.

1) Execute the command `AT+SYSLOG?` to query the log settings of the system.

2) From the query result, search for the configuration for HAL ("hal", 0, 1) which indicates the HAL log is enabled and the debug level is set to WARNING to print the HAL warning and error messages.

3) Execute the AT command `AT+SYSLOG="hal",0,0` to change the debugging level of HAL to INFO level. You can confirm the update by executing the command `AT+SYSLOG?`. The HAL setting will become ("hal", 0, 0) after the command is issued and the HAL INFO message will be printed in the log terminal.

The log settings for HAL remain effective even after the device resets.

To update the settings for all modules, use the wild card "*", such as the command `AT+SYSLOG="*",1,1` turns off the system logging and changes the debug level to WARNING for all modules.

```plaintext
AT+SYSLOG=
+SYSLOG:
(AT+SYSLOG?, query for the current setting)
(AT+SYSLOG=<module>,<log_switch>,<print_level>, config module's setting)
(<log_switch> = 0|1(meaning on|off), <print_level=0|1|2(meaning I/W/E))
OK
AT+SYSLOG?
+SYSLOG:
("a2dp",1,0),("atci",0,0),("atci bt",0,0),("atci_charger",0,0),("atci_cwp",0,0),
("atci_keypad",0,0),("atci_reg",0,0),("atcmd",0,0),("audio middleware api",0,0),
("audio_nvdm",0,0),("av util",0,0),("avrcp",1,0),("ble gatt_bqb",0,0),
("ble gatt cmd",0,0),("ble l2cap_bqb",0,0),("ble_sm_bqb",0,0),("BLEQB",0,0),
("bmt",0,0),("BQBMAIN",0,0),("bt",0,0),("bt_clm",0,0),("bt_pbapc",0,0),
("bt_pbapc_clm",0,0),("bt_sdp_bqb",0,0),("bt_spp_bqb",0,0),("CLM_GAP",0,0),
("common",0,0),("DOGP ADP",0,0),("fota dl m",0,0),("GAP BQB",0,0),("GATT SVR",0,0),
("GNSS_TAG",0,0),("hal",0,1),("RTC ATCI",0,0),("sensor",0,0),("testframework",0,0),
("SP_PORT",0,1),("bt spp",0,1)
OK
AT+SYSLOG="hal",0,0
OK
AT+SYSLOG?
+SYSLOG:
("a2dp",1,0),("atci",0,0),("atci bt",0,0),("atci_charger",0,0),("atci_cwp",0,0)
```
1.3.2. CLI commands

The CLI commands are applicable to LinkIt 7687 HDK only, as shown in Table 2.

Table 2. CLI commands for the LinkIt 7687 HDK

<table>
<thead>
<tr>
<th>Function</th>
<th>Command</th>
</tr>
</thead>
<tbody>
<tr>
<td>Query for the usage</td>
<td>$log set</td>
</tr>
<tr>
<td>Query for the current setting</td>
<td>$log</td>
</tr>
<tr>
<td>Update the settings of a module</td>
<td>$log set &lt;module&gt; &lt;log switch&gt; &lt;print_level&gt;</td>
</tr>
<tr>
<td></td>
<td>&lt;module&gt;: module name</td>
</tr>
<tr>
<td></td>
<td>&lt;log switch&gt;: on, off</td>
</tr>
<tr>
<td></td>
<td>&lt;print_level&gt;: info, warning, error</td>
</tr>
</tbody>
</table>

1.3.2.1. CLI command example

In this example, the following log modules are presented — main, common, HAL, lwIP, minisupp, inband, Wi-Fi and Bluetooth. The HAL log is enabled and the debug level is set as warning to print warning and error messages.

The debug level of HAL is updated to INFO with the CLI command - $log set hal on info. After the command is issued, the HAL INFO message will be printed in the log terminal. The setting for HAL is still effective after the device is powered down and up again. There is a special command by specifying the module name as the wild card "*" to update the setting for all modules. For example, the command $log set * off warning will turn off logging and update the debug level as WARNING for all modules.

$ log
log
module on/off level
------- ------- -----
main on error
common on warning
hal on warning
lwip on error
minisupp on error
### 1.4. Multitasking support

Since there is only one serial port for system logging, a single log task is created to write the output log data to the serial port when it is scheduled. The other tasks call the System Log API to allocate a log buffer, format the log data by calling the C library function offered by the toolchain and send the log data to the log task. A fixed number of log buffers are allocated as a shared resource. The allocation and release of a log buffer is protected to ensure only one task can access it at a time.

### 1.5. Supported printf() function

Syslog calls the printf() function implemented in the toolchain (GCC, KEIL, IAR). In GCC, the floating print function (%f) is not enabled by default. To enable it, specify it in linker flag (LDFLAGS += -u __printf_float). However, it should be noted that the code size will increase if floating print is enabled.
1.6. Conditional compile options

The project makefile’s feature flag `MTK_DEBUG_LEVEL` defines whether a particular debug log will be compiled. It can be configured in project’s `feature.mk` makefile. More compile options are described in Table 3.

<table>
<thead>
<tr>
<th>MTK_DEBUG_LEVEL</th>
<th>The effect of the setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>none</td>
<td>All logs are removed.</td>
</tr>
<tr>
<td>info</td>
<td><code>LOG_I, LOG_W, LOG_E, LOG_HEXDUMP_I, LOG_HEXDUMP_W, LOG_HEXDUMP_E</code> are compiled.</td>
</tr>
<tr>
<td>warning</td>
<td><code>LOG_W, LOG_E, LOG_HEXDUMP_W, LOG_HEXDUMP_E</code> are compiled.</td>
</tr>
<tr>
<td>error</td>
<td><code>LOG_E, LOG_HEXDUMP_E</code> are compiled.</td>
</tr>
</tbody>
</table>
2. System Log APIs

This section describes the source code and header file hierarchy for the System Log and their usage. The files could be found under `<sdk_root>/kernel/service/src_core`.

Table 4 provides details on the main functions of the System Log tree hierarchy.

### Table 4. System Log source code description

<table>
<thead>
<tr>
<th>File</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;project&gt;/GCC/feature.mk</td>
<td>Define MTK_DEBUG_LEVEL</td>
</tr>
<tr>
<td>kernel/service/inc/syslog.h</td>
<td>The main header file for the System Log. It includes the macros and APIs for initialization, logging and filtering purposes.</td>
</tr>
<tr>
<td>kernel/service/src/src_core/syslog.c</td>
<td>Contains the internal implementation of the System Log API. It also declares the log control block for a common module that enables the user to print log messages of the common module.</td>
</tr>
<tr>
<td>kernel/service/src/syslog_cli.c</td>
<td>Includes the syslog CLI commands for LinkIt 7687 HDK.</td>
</tr>
<tr>
<td>middleware/MTK/atci/at_command/at_command_syslog.c</td>
<td>Includes the syslog AT commands for LinkIt 2523 HDK.</td>
</tr>
</tbody>
</table>

#### 2.1. Supported APIs

The following lists the most commonly used APIs.

##### 2.1.1. `log_init()`

**Description**

This function initializes the system log. The syslog control blocks table (see section 1.3, “Log setting commands”) is used in syslog related AT and CLI commands.

**Parameter**

- `syslog_save_fn`: User-defined callback function to store log settings.
- `syslog_load_fn`: User-defined callback function to read log settings.
- `log_control_block_t **entries`: A pointer to syslog control blocks table for the project.

##### 2.1.2. `LOG_CONTROL_BLOCK_DECLARE()`

**Description**

This macro declares the external reference to a log control block (see section 1.3, “Log setting commands”) of a module.

**Parameter**

- `module`: Module name.

##### 2.1.3. `LOG_CONTROL_BLOCK_SYMBOL`

**Description**

This macro refers to the log control block (see section 1.3, “Log setting commands”) of a module.

**Parameter**

- `module`: Module name.
2.1.4. **log_create_module()**

<table>
<thead>
<tr>
<th>Description</th>
<th>This macro creates the log control block of a module.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameter</td>
<td><strong>module</strong>. Module name.</td>
</tr>
<tr>
<td></td>
<td><strong>level</strong>. &quot;PRINT_LEVEL_INFO&quot;, the debug level for the module is INFO.</td>
</tr>
<tr>
<td></td>
<td>&quot;PRINT_LEVEL_WARNING&quot;, the debug level for the module is WARNING.</td>
</tr>
<tr>
<td></td>
<td>&quot;PRINT_LEVEL_ERROR&quot;, the debug level for the module is ERROR.</td>
</tr>
</tbody>
</table>

2.1.5. **log_config_print_switch()**

<table>
<thead>
<tr>
<th>Description</th>
<th>This macro configures whether the log for the module is enabled.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameter</td>
<td><strong>module</strong>. Module name.</td>
</tr>
<tr>
<td></td>
<td><strong>log_switch</strong>. &quot;DEBUG_LOG_ON&quot;, the log for the module is enabled.</td>
</tr>
<tr>
<td></td>
<td>&quot;DEBUG_LOG_OFF&quot;, the log for the module is disabled.</td>
</tr>
</tbody>
</table>

2.1.6. **log_config_print_level()**

<table>
<thead>
<tr>
<th>Description</th>
<th>This macro configures the debug level for the module.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameter</td>
<td><strong>module</strong>. Module name.</td>
</tr>
<tr>
<td></td>
<td><strong>log_switch</strong>. &quot;PRINT_LEVEL_INFO&quot;, the debug level of the module is INFO.</td>
</tr>
<tr>
<td></td>
<td>&quot;PRINT_LEVEL_WARNING&quot;, the log level of the module is WARNING.</td>
</tr>
<tr>
<td></td>
<td>&quot;PRINT_LEVEL_ERROR&quot;, the debug level of the module is ERROR.</td>
</tr>
</tbody>
</table>

2.1.7. **LOG_I**

<table>
<thead>
<tr>
<th>Description</th>
<th>This macro adds an INFO log message.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameter</td>
<td><strong>module</strong>. Module name.</td>
</tr>
<tr>
<td></td>
<td><strong>message</strong>. Format specifiers.</td>
</tr>
<tr>
<td></td>
<td><strong>variadic arguments</strong>. The parameters corresponding to the format specifiers defined in the message parameter.</td>
</tr>
</tbody>
</table>

2.1.8. **LOG_W**

<table>
<thead>
<tr>
<th>Description</th>
<th>This macro adds a WARNING log message.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameter</td>
<td><strong>module</strong>. Module name.</td>
</tr>
<tr>
<td></td>
<td><strong>message</strong>. Format specifiers.</td>
</tr>
<tr>
<td></td>
<td><strong>variadic arguments</strong>. The parameters corresponding to the format specifiers defined in the message parameter.</td>
</tr>
</tbody>
</table>

2.1.9. **LOG_E**

<table>
<thead>
<tr>
<th>Description</th>
<th>This macro adds an ERROR log message.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameter</td>
<td><strong>module</strong>. The module name.</td>
</tr>
<tr>
<td></td>
<td><strong>message</strong>. Format specifiers.</td>
</tr>
<tr>
<td></td>
<td><strong>variadic arguments</strong>. The parameters corresponding to the format specifiers defined in the message parameter.</td>
</tr>
</tbody>
</table>
2.1.10. LOG_HEXDUMP_I

<table>
<thead>
<tr>
<th>Description</th>
<th>This macro adds an INFO log message and displays the contents of a specified range of memory. The memory is displayed in hexadecimal format.</th>
</tr>
</thead>
</table>
| Parameter   | module. The module name.  
message. Format specifiers.  
data. The start address of the memory region to be displayed.  
len. The length of the memory region to be displayed, in bytes.  
variadic arguments. The parameters corresponding to the format specifiers defined in the message parameter. |

2.1.11. LOG_HEXDUMP_W

<table>
<thead>
<tr>
<th>Description</th>
<th>This macro adds a WARNING log message and displays the contents of a specified range of memory. The memory is displayed in hexadecimal format.</th>
</tr>
</thead>
</table>
| Parameter   | module. The module name.  
message. Format specifiers.  
data. The start address of the memory region to be displayed.  
len. The length of the memory region to be displayed, in bytes.  
variadic arguments. The parameters corresponding to the format specifiers defined in the message parameter. |

2.1.12. LOG_HEXDUMP_E

<table>
<thead>
<tr>
<th>Description</th>
<th>This macro adds an ERROR log message and displays the contents of a specified range of memory. The memory is displayed in hexadecimal format.</th>
</tr>
</thead>
</table>
| Parameter   | module. The module name.  
message. Format specifiers.  
data. The start address of the memory region to be displayed.  
len. The length of the memory region to be displayed, in bytes.  
variadic arguments. The parameters corresponding to the format specifiers defined in the message parameter. |

2.2. System Log API usage

In this section, the System Log APIs are utilized to create and configure logs for a specific module. A user defined function is then invoked to demonstrate the logging operation for different levels of log configuration.

The code below declares a log control block for the Hardware Abstraction Layer (HAL) module. In this example, the log level for HAL is configured as PRINT_LEVEL_WARNING. Call log_create_module to set the configuration, as shown below.

```c
#include "syslog.h"
log_create_module(hal, PRINT_LEVEL_WARNING);
```

A log control block for the HAL module with the content shown below is created:

```c
log_control_block_t log_control_block_hal =
```
The following user defined function (demo_function()) demonstrates the usage of the System Log API. Only the log messages with a print level greater than or equal to PRINT_LEVEL_WARNING will be printed.

```c
void demo_function(int id1, int id2, char *statement)
{
    LOG_I(hal, "INFO message %d\n", id1);         /* It is not printed */
    LOG_W(hal, "WARNING message %d\n", id2);      /* It is printed */
    LOG_E(hal, "ERROR message %s\n", statement);  /* It is printed */
}
```

### 2.3. System Log output format

Each log message includes a log header and a log body. The log header shows **timestamp, module name, level, function**, and **line number**. The log body shows the user-defined log.

[T: 20761 M: hal C: INFO F: vTestTask L: 824]: CM4 Task 0 Hello World, Idx = 10

### 2.4. System Logs attached to a task

System Logs could be associated with hardware related tasks. Apply the reference application (freertos_thread_creation) available in the SDK to create your own applications. System Log APIs are called to print the last execution time and the stack dump of a specific task.

The reference application can be found at

```c
<sdk_root>/project/mt2523_hdk/apps/freertos_thread_creation/src/main.c
<sdk_root>/project/mt7687_hdk/apps/freertos_thread_creation/src/main.c
```

There are four instances of vTestTask task created. Each instance of the vTestTask task prints its own logs independently.

1) Creating the tasks.

Create four instances of vTestTask in main function by calling xTaskCreate() function. Each task requires a task number. The idx parameter represents the task number.

```c
//Create the log control block for freertos module
log_create_module(hal, PRINT_LEVEL_INFO);
```
int main(void) {
...  int idx = 0;
...
for(idx=0;idx<4;idx++)
{
  xTaskCreate(vTestTask, "Test", 1024, (void*)idx, 2, NULL);
}
...
}

2) Declaring and initializing the variables.

The function begins with declaring several parameters for further use, as follows:

```c
static void vTestTask( void *pvParameters )
{
  int i = 0;
  int idx = (int)pvParameters;
  portTickType xLastExecutionTime;
  char * stack;
```

3) Continuous looping.

Start a continuous while loop, then call a function vTaskDelay(300) to repeat the operation of the loop content for each 300 milliseconds. The loop index i is then updated and the variable xLastExecutionTime is assigned to the system tick count obtained from xTaskGetTickCount() function.

```c
while (1) {
  vTaskDelay(300);
  i++;
  //configASSERT(i < 1000);
  xLastExecutionTime = xTaskGetTickCount();
```

4) Printing the System Logs.

In line 329 of vTestTask() function, the INFO log message is printed in every loop.

In line 333 of vTestTask() function, the INFO log message with memory dump is printed, if the loop index i is 256*n, where n is a positive integer (≥0).
In line 336 of `vTestTask()` function, the WARNING log message with memory dump is printed, if the loop index `i` is \((256n + 128)\), where \(n\) is a positive integer (\(\geq 0\)).

```c
LOG_I (hal, "CM4 Task %d Hello World, Cnt=%d, xLastExecutionTime = %x\n", idx, i, (int)xLastExecutionTime);
    if (i % 128 == 0) {
        __asm volatile("mov %0, r13" : "=r" (stack) );
        if ( i % 256 == 0) {
            LOG_HEXDUMP_I (hal, "Task ID: %d, Stack Dump -->\n", (char*)stack, 128, idx);
        } else {
            LOG_HEXDUMP_W (hal, "Task ID: %d, Stack Dump -->\n", (char*)stack, 128, idx);
        }
```

The full source code of the function is shown below:

```c
static void vTestTask( void *pvParameters )
{
    int i=0;
    int idx = (int)pvParameters;
    portTickType xLastExecutionTime;
    char * stack;

    while (1) {
        vTaskDelay(300);
        i++;
        //configASSERT(i < 1000);
        xLastExecutionTime = xTaskGetTickCount();
        LOG_I(hal, "CM4 Task %d Hello World, Cnt=%d, xLastExecutionTime = %x\n", idx, i, (int)xLastExecutionTime);
        if (i % 128 == 0) {
            __asm volatile("mov %0, r13" : "=r" (stack) );
            if ( i % 256 == 0) {
                LOG_HEXDUMP_I (hal, "Task ID: %d, Stack Dump -->\n", (char*)stack, 128, idx);
            } else {
                LOG_HEXDUMP_W (hal, "Task ID: %d, Stack Dump -->\n", (char*)stack, 128, idx);
            }
```
A snapshot of execution result is shown in Figure 2 and Figure 3 with a loop index of 128 and 256, respectively.

Figure 2. Example output of `freertos_thread_creation` (loop index = 128)
Figure 3. Example output of freertos_thread_creation (loop index = 256)
3. Host UART Configuration

The System Log messages on the host side are displayed using a terminal program, such as TeraTerm and Putty. The terminal program is able to receive text data from the serial port. TeraTerm terminal program is selected for the demonstration purposes. The hardware development board is the LinkIt 7687 development board.

The host UART settings are configured as follows:

1) Set up the port.
   a) Open Windows Control Panel then click System and:
      o On Windows 7 and 8, click Device Manager.
      o On Windows XP, click the Hardware tab and then Device Manager.
   b) In Device Manager, navigate to Ports (COM & LPT) (see Figure 4).
   c) Connect the development board to your computer using a Micro-USB cable.
   d) A new COM device should appear under Ports (COM & LPT) in Device Manager, as shown in Figure 4. Note the COMx port number of the serial communication port, this information is needed to complete configuration of the Tera Term terminal program.

2) Launch the Tera Term terminal program and open the Serial port setup window.
   a) Assign the COM port number found in Set up the port. The rest of the parameters such as Baud rate, Data, Parity, Stop and Flow control should be defined, as shown in Figure 5.
Figure 4. Enumerated COM port on the host

Figure 5. UART configurations in Tera Term terminal program
4. Exception Handler

Exception handler assists in debugging programming errors. When exception occurs, the content of the processor’s core registers and memory are dumped into a log file. The data in the dump file can be analyzed given the symbol information in the corresponding ELF file. Exceptions are either processor detected exceptions or user defined assert failures. Four types of hardware exceptions are supported in Exception Handler for ARM Cortex-M4: **HardFault**, **MemMange**, **BusFault**, and **UsageFault**. Refer to ARM v7-M Architecture Reference Manual for more detail.

Table 5 describes the source code and header file hierarchy for the Exception Handler and their usage.

<table>
<thead>
<tr>
<th>File</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>kernel/service/inc/exception_handler.h</td>
<td>The main header file for the Exception Handler. It includes data types and APIs.</td>
</tr>
<tr>
<td>kernel/service/src/src/memory_regions.c</td>
<td>Contains the system memory map definition to facilitate the Exception Handler to dump memory. It is mainly a table of linker generated symbols of the system.</td>
</tr>
<tr>
<td>kernel/service/src_core/exception_handler.c</td>
<td>Contains the internal implementation of the Exception Handler.</td>
</tr>
</tbody>
</table>

4.1. Supported APIs

The following lists the most commonly used APIs.

4.1.1. `configASSERT()`

| Description | Use this macro to add assert expression. If the expression is evaluated as FALSE, `platform_assert()` is called. |
| Parameter | `expr`. The expression to be evaluated. |

4.1.2. `abort()`

| Description | A porting function used in GCC toolchain. It’s linked with toolchain’s `assert()`. |
| Parameter | `none` |

4.1.3. `__aeabi_assert()`

| Description | A porting function used in Keil or IAR embedded workbench toolchain. It’s linked with tool chain’s `assert()`. |
| Parameter | `const char *expr`. User-defined assert expression. `const char *file`. Source file where assert expression is added. `int line`. Line number of the assert expression. |
4.1.4.  **platform_assert()**

**Description**
This function is called when assert check fails. It’s used in the configASSERT macro. It intentionally performs invalid memory access to bring the system into exception.

**Parameter**
- `const char *expr`. User-defined assert expression.
- `const char *file`. Source file where assert expression is added.
- `int line`. Line number of the assert expression.

4.1.5.  **exception_register_callbacks()**

**Description**
Users can register `init_cb` and or `dump_cb`. `init_cb` is called when exception occurs. It’s designed for user-defined functions, such as trigger system log buffer flush operation. `dump_cb` is called after memory dump is complete.

**Parameter**
- `exception_config_type *cb`. User-defined callback functions.

4.1.6.  **exception_dump_config()**

**Description**
This function is used to customize the exception handler behavior.

**Parameter**
- `int flag`.
  - DISABLE_MEMDUMP_MAGIC: Exception handler calls `exception_reboot()` after dumping the core registers.
  - Other values: no effect, reserved for future use.

4.1.7.  **exception_reboot()**

**Description**
The exception handler calls this function after the core register is dumped if the memory dump feature is disabled (see section 4.1.6, “exception_dump_config()”). `exception_reboot()` is implemented as a weak function in exception handler to allow user customization as the reboot function is chip and project dependent (see section 4.3, “Reboot without memory dump on exception”).

**Parameter**
- `none`

4.2.  **Enable exception handling in projects**

For GCC environment, users need to include `kernel/service/module.mk` in the project’s Makefile.

```makefile
# kernel service files
include $(SOURCE_DIR)/kernel/service/module.mk
"project/mt2523_hdk/apps/iot_sdk_demo/GCC/Makefile" 300 lines --25%--
```

To enable exception handling for applications in Keil IDE or IAR embedded workbench environments, include a prebuilt kernel service library and `memory_regions.c` source file into the project’s configuration file. An example project in Keil IDE and IAR embedded workbench IDE is shown in Figure 6 and Figure 7, respectively.
Figure 6. Enable exception handling in Keil IDE
It's suggested to use `configASSERT()` instead of `assert()`. The "__noreturn__" attribute specified for the `assert()` function, informs the compiler that the function does not return. The compiler, performing
optimization, may not save the key registers necessary for callstack unwind. The configASSERT() macro is defined in the project’s FreeRTOSConfig.h.

```
#if defined(__ICCARM__) || defined(__CC_ARM) || defined(__GNUC__)
extern void abort(void);
extern void platform_assert(const char *, const char *, int);
...
#define configASSERT( x ) if( (x) == 0 ) { platform_assert(#x, __FILE__, __LINE__); }
#include "syslog.h"
#endif /*#if defined(__ICCARM__) || defined(__CC_ARM) || defined(__GNUC__)*/
```

The project’s memory map defined in kernel/service/src/memory_regions.c facilitates the exception handler to create a memory dump. It’s a table of the linker-generated symbols specifying the location of image sections.

```
const memory_region_type memory_regions[] =
{
   {"ram_text", Image$$RAM_TEXT$$Base, Image$$RAM_TEXT$$Limit, 1},
   {"noncached_data", Image$$NONCACHED_DATA$$Base, Image$$NONCACHED_ZI$$Limit, 1},
   {"cached_data", Image$$CACHED_DATA$$RW$$Base, Image$$CACHED_DATA$$ZI$$Limit, 1},
   {"tcm", Image$$TCM$$RO$$Base, Image$$STACK$$ZI$$Limit, 1},
   {"stack", Image$$STACK$$ZI$$Base, Image$$STACK$$ZI$$Limit, 0},
   {"scs", (unsigned int*)SCS_BASE, (unsigned int*)(SCS_BASE + 0x1000), 1},
   {0}
};
"kernel/service/src/memory_regions.c"
```

### 4.3. Reboot without memory dump on exception

Users should call exception_dump_config(DISABLE_MEMDUMP_MAGIC) during system initialization and implement the exception_reboot() function. Normally reboot can be implemented by hardware watchdog. Refer to HAL/WDT section in `<SDK_root>/doc/LinkIt SDK for Chipset API Reference Manual.html`, for more details.

### 4.4. Exception Dump Example

An exception dump examples for MT2523 are shown in Figure 8 to Figure 10. The exception is triggered by the AT command "AT+SYSTEM=crash". When the program reaches the line 244 of at_command_system.c, the system crashes due to assert check failure.

```
/* AT command handler */
```
atci_status_t atci_cmd_hdlr_system(atci_parse_cmd_param_t *parse_cmd)
{
    char *param = NULL, *saveptr = NULL;
    atci_response_t *presponse = pvPortMalloc(sizeof(atci_response_t));
...
    case ATCI_CMD_MODE_EXECUTION: /* rec: AT+SYSTEM=<module> */
    ...
    } else if (strcmp(param, "crash") == 0) {
        strncpy((char *)(presponse->response_buf),
            "+SYSTEM:\r\n system will crash...\r\n",
            (int32_t)ATCI_UART_TX_FIFO_BUFFER_SIZE);
        presponse->response_len = strlen((char *)(presponse->response_buf));
        presponse->response_flag = ATCI_RESPONSE_FLAG_APPEND_OK;
        atci_send_response(presponse);
        configASSERT(0);
    } else {
...

"middleware/MTK/atci/at_command/at_command_system.c"

The system is working properly before the AT command is issued which is obvious from the AT command logs.

After an exception occurs, the exception handler initializes and calls the registered exception callbacks. By design, the system log service module registers an exception initialization callback to flush the last minute logs still in the log buffer. There is a hint message ">>> dump syslog buffer" followed by the flushed logs ordered by logging time (see Figure 8).
Figure 8. Exception dump Example (1/3)

The asserted expression, source file and line number are displayed next. In this case, the exception occurs in line 244 of `at_command_system.c`.

```
assert failed: 0,
file: ../../../../../middleware/MTK/atci/at_command/at_command_system.c,
line: 244
```

After the “assert failed:” message, the exception type and the core registers’ values are logged, as shown in Figure 9.
Then the system memory is dumped and "memory dump completed." message is displayed, as shown in Figure 10.
Figure 10. Exception dump example (3/3)