CPU Program Counter/Register Self-diagnosis Program Application Note

Outlines

This application note describes the self-diagnosis program for the CPU.
The self-diagnosis program in this document is the library which checks the CPU program counters and registers.
This library supports the sample program with the peripheral driver of TXZ series enclosed, and should be used after it is overwritten to the sample program.

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1. Preface

This application note describes the self-diagnosis program which uses the CPU program counter test and register test.
This library code should be used after it is added (overwritten) to the published sample program.

The explanation of this document uses the TMPM4K Group (1).
When the program is applied to a product, some appropriate modification may be necessary depending on the specifications of the product.

This sample program has been developed and evaluated under the conditions in the operation confirmation environment in “Self-diagnosis Program Application Note – Basic Setting”, and by using the TMPM4K4A 1.0.0 sample program and the reference manual released in February in 2019.

2. Outline of Self-diagnosis Test Library

This self-diagnosis test library has been checked on the evaluation board.

The following self-test function is supported.

Name	Description
CPU register test	All writable and readable registers are tested. The checker patterns of 0x55555555 and 0xAAAAAAAA are written to the registers and read from the registers. It is checked whether the read data is correct or not.
CPU program counter test	After a jump instruction is executed, it is checked that the value in the PC is the same as the expected value at describing the program (at the build). 10 jump destination addresses are prepared. When all jumps are executed correctly, the program step returns to the source address of the call.

2.1. Self-diagnosis Sample Project

In the "Project\Examples\Safety" folder, the following sample project for the self-diagnosis library is placed.

Project name	Operation	Utilized self-diagnosis library function

CPU_Sample	The CPU register test and the CPU program counter test are executed. The result is shown with the LED lighting.	safety_CPU_Register()
		safety_CPU_ProgramCounter()

3. Details of Self-diagnosis Test Library

This section describes the details of the self-diagnosis test library function.
This sample program is a self-diagnosis program for the CPU program counters and registers.
The following setting is an example when a product in the TMPM4K group (1) is used.

The source code (.c file) of the self-diagnosis library is in the “Libraries\Safety\src” folder, and the header file (.h file) is in the “Libraries\Safety\inc” folder.

3.1. CPU Register Test

“Stuck at” error check(Note1) for the CPU registers is done to the following CPU registers.

- R0 to R12
- R13 (Main SP and Process SP) (Note2)
- R14 (LR)
- CPSR (only upper 5 bits)

The CPU register test checks the registers in turn.

When an error of a register is detected, the test is suspended and the error result is returned. The bit mask value which identifies the register is also returned.
The library function is supposed to be called in the privilege status (not the user status).
This library function should be called while the interrupts are disabled.
The registers which are set to non-destructive ones at the call in C-language are protected before and after the test execution.

The “safety_CPU_Register” function does not use any interrupts.

Source file: safety_cpu_reg.c
Header file: safety_cpu_reg.h
Used library: txz_gpio.c/.h

Function name	
bool safety_CPU_Register(uint32_t *result_word)	
Input parameter	
None.	-
Output parameter	
uint32_t *result_word	Memory buffers which store the results. bit0 to bit12: R0 to R12 test failure bit13: Main SP test failure bit14: Process SP test failure bit15: LR test failure bit16: CPSR test failure
Return value	
bool	Test result (true: success, false: failure)

* If the return value cannot be confirmed for several seconds, it is supposed the test is not executed correctly.
The process for the test failure should be done.
When, however, the terminal I/O output display is used, it takes several seconds to complete the display.
The judgment of the test failure should be done by checking the display.

Note1: "Stuck at" check detects the abnormal error that a bit value is fixed to 0 or 1.
Note2: The least 2 bits of the SP register are fixed to 0. These bits are not tested.

3.2. CPU Program Counter Test

“Stuck at” error is checked for the CPU program counter.
Multiple jump instructions are executed in this function instead that the program counter is set to a value.
If the test fails, the program has some error. The error in the program cannot be recovered automatically.

On the other hand, when the execution completes, the test is successful.

This library function should be called while the interrupts are disabled. The registers which are set to non-destructive ones at the call in C-language are protected before and after the test execution.

The “safety_CPU_ProgramCounter” function does not use any interrupts.

Source file: safety_cpu_pc.c
Header file: safety_cpu_pc.h
Used library: txz_gpio.c/.h

Function name	
bool safety_CPU_ProgramCounter(void)	
Input parameter	
None.	-
Output parameter	
None.	-
Return value	
bool	Test result When the test completes correctly, “true: success” returns. When it fails, the program step does not return to the source address of the call. If “false” returns, an internal error may exist in the program such as a compilation error and others. (Note1)

* When the terminal I/O output display is used, it takes several seconds to complete the display. The judgment of the test failure should be done by checking the display.

The test result is shown with the LEDs after all the tests finish on the evaluation board which was used to develop this test program.
LED1 (PJ0) lighting: All tests are successful.
LED2 (PJ2) lighting: Register test fails.
LED3 (PJ4) lighting: Program counter test fails.

Note1: This may happen when the inline expansion is done for the called subroutine and others. This test implementation invalidates the inline expansion of the functions.

4. List of Used Drivers

This test library uses the driver and the code in the project of the TMPM4KxA_v1.0.0 version.

CMSIS library

Category	Source file name
Start-up	startup_TMPM4K4A.s
System (Clock setting and others)	system_TMPM4KxA.c

Periph_driver

Category	Source file name
GPIO	txz_gpio.c

In the Project examples

Category	Source file name
BSP (Evaluation board support)	bsp.c
LED output	bsp_led.c

5. Reference Document

For development, refer to the following documents.

- Datasheet of each product
- Reference Manual
- Self-diagnosis Program Application Note - Basic Setting
- ARM® Cortex®-M4 Processor technical Reference Manual
- ARMv7-M Architecture Reference Manual

6. Revision History

Revision	Date	Description
1.0	2019-08-30	First release

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