

Errata

MSP430FR5994 Microcontroller



ABSTRACT

This document describes the known exceptions to the functional specifications (advisories).

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1 Functional Advisories

Advisories that affect the device's operation, function, or parametrics.

✓ The check mark indicates that the issue is present in the specified revision.

Errata Number	Rev C
ADC42	✓
ADC65	✓
ADC69	✓
CPU46	✓
CPU47	✓
CS12	✓
PMM31	✓
PMM32	✓
RTC12	✓
USCI42	✓
USCI45	✓
USCI47	✓
USCI50	✓

2 Preprogrammed Software Advisories

Advisories that affect factory-programmed software.

✓ The check mark indicates that the issue is present in the specified revision.

Errata Number	Rev C
ADC67	✓

3 Debug Only Advisories

Advisories that affect only debug operation.

✓ The check mark indicates that the issue is present in the specified revision.

The device does not have any errata for this category.

4 Fixed by Compiler Advisories

Advisories that are resolved by compiler workaround. Refer to each advisory for the IDE and compiler versions with a workaround.

✓ The check mark indicates that the issue is present in the specified revision.

Errata Number	Rev C
CPU21	✓
CPU22	✓
CPU40	✓

Refer to the following MSP430 compiler documentation for more details about the CPU bugs workarounds.

TI MSP430 Compiler Tools (Code Composer Studio IDE)

- [MSP430 Optimizing C/C++ Compiler](#): Check the --silicon_errata option
- [MSP430 Assembly Language Tools](#)

MSP430 GNU Compiler (MSP430-GCC)

- [MSP430 GCC Options](#): Check -msilicon-errata= and -msilicon-errata-warn= options
- [MSP430 GCC User's Guide](#)

IAR Embedded Workbench

- [IAR workarounds for msp430 hardware issues](#)

5 Nomenclature, Package Symbolization, and Revision Identification

The revision of the device can be identified by the revision letter on the [Package Markings](#) or by the [HW_ID](#) located inside the TLV structure of the device.

5.1 Device Nomenclature

To designate the stages in the product development cycle, TI assigns prefixes to the part numbers of all MSP MCU devices. Each MSP MCU commercial family member has one of two prefixes: MSP or XMS. These prefixes represent evolutionary stages of product development from engineering prototypes (XMS) through fully qualified production devices (MSP).

XMS – Experimental device that is not necessarily representative of the final device's electrical specifications

MSP – Fully qualified production device

Support tool naming prefixes:

X: Development-support product that has not yet completed Texas Instruments internal qualification testing.

null: Fully-qualified development-support product.

XMS devices and X development-support tools are shipped against the following disclaimer:

"Developmental product is intended for internal evaluation purposes."

MSP devices have been characterized fully, and the quality and reliability of the device have been demonstrated fully. TI's standard warranty applies.

Predictions show that prototype devices (XMS) have a greater failure rate than the standard production devices. TI recommends that these devices not be used in any production system because their expected end-use failure rate still is undefined. Only qualified production devices are to be used.

TI device nomenclature also includes a suffix with the device family name. This suffix indicates the temperature range, package type, and distribution format.

5.2 Package Markings

ZVW87

NFBGA (ZVW), 87 pin

<div> <div>MSP430™</div> <div>FRxxxx</div> <div>NNNNNNN #</div> <div>TI <u>G1</u></div> <div>○</div> </div>	<div># = Die revision</div> <div>○ = Pin 1 location</div> <div>N = Lot trace code</div>
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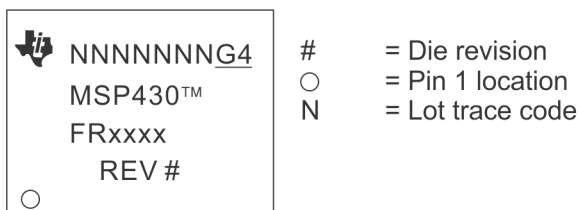
RGZ48

QFN (RGZ), 48 Pin

<div> <div>○</div> <div>MSP430™</div> <div>FRxxxx</div> <div>TI NNN #</div> <div>NNNN <u>G4</u></div> </div>	<div># = Die revision</div> <div>○ = Pin 1 location</div> <div>N = Lot trace code</div>
--	---

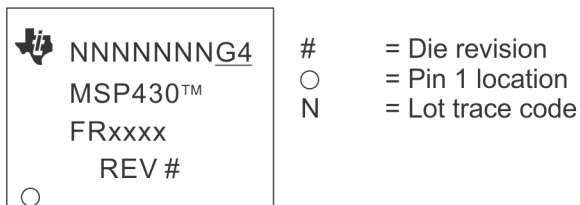
PM64

LQFP (PM), 64 Pin



PN80

LQFP (PN), 80 Pin



5.3 Memory-Mapped Hardware Revision (TLV Structure)

Die Revision	TLV Hardware Revision
Rev C	21h

Further guidance on how to locate the TLV structure and read out the HW_ID can be found in the device User's Guide.

6 Advisory Descriptions

ADC42 *ADC Module*

Category Functional

Function ADC stops converting when successive ADC is triggered before the previous conversion ends

Description Subsequent ADC conversions are halted if a new ADC conversion is triggered while ADC is busy. ADC conversions are triggered manually or by a timer. The affected ADC modes are:

- sequence-of-channels
- repeat-single-channel
- repeat-sequence-of-channels (ADC12CTL1.ADC12CONSEQx)

In addition, the timer overflow flag cannot be used to detect an overflow (ADC12IFGR2.ADC12TOVIFG).

Workaround

1. For manual trigger mode (ADC12CTL0.ADC12SC), ensure each ADC conversion is completed by first checking ADC12CTL1.ADC12BUSY bit before starting a new conversion.
2. For timer trigger mode (ADC12CTL1.ADC12SHP), ensure the timer period is greater than the ADC sample and conversion time.

To recover the conversion halt:

1. Disable ADC module (ADC12CTL0.ADC12ENC = 0 and ADC12CTL0.ADC12ON = 0)
2. Re-enable ADC module (ADC12CTL0.ADC12ON = 1 and ADC12CTL0.ADC12ENC = 1)
3. Re-enable conversion

ADC65 *ADC Module*

Category Functional

Function ADC12_B clock stays on between conversions in sequence-of-channels or repeated sequence-of-channels mode

Description When using the ADC in sequence-of-channels or repeat-sequence-of-channels mode (ADC12CONSEQx = 01 or 11), the ADC12_B always requests the ADC clock even between conversions. In this scenario, although the device may still enter LPM0, LPM1, LPM2 or LPM3, the selected ADC12_B clock source will always remain on, resulting in increased current consumption between ADC conversions.

Workaround To avoid the additional current consumption impact, different options will be needed depending on use case:

1. Configure ADC to Repeated-Single-Channel mode (ADC12CONSEQx = 10). Use the DMA or software to change the selected ADC12INCHx between conversions. With this option, the timing between conversions of different channels remains the same as normal

ADC12 usage.

OR

2. Configure ADC to Sequence-of-Channels mode (ADC12CONSEQx = 01) with sequence of channels in Multiple Sample and Convert mode (ADC12CTL0.ADC12MSC = 1), then toggle the ADC12ENC bit by DMA or software after completing of each conversion sequence. With this option, the conversions of each channel in the sequence will happen immediately after the previous channel instead of waiting for the next trigger. This needs to be considered if timing between the sampling of different channels in the sequence matters for the application.

ADC67

ADC Module

Category

Software in ROM

Function

Invalid ADC12 temperature sensor calibration data

Description

The ADC12 reference temperature sensor calibration data stored in the TLV data structure (0x1A1A - 0x1A25) can be incorrect depending on the production lot trace code. As a result the temperature measurement when using these data can be wrong.

Devices with lot trace code > 87XXXXX are not affected by this issue.

Workaround

Record the calibration data by taking ADC measurements of the temperature sensor at 30C and 85C for the required reference voltage. The calibration data in the TLV section (0x1A1A - 0x1A25) can't be overwritten but the new calibration data can be stored in user FRAM or info memory for further temperature calculations.

ADC69

ADC Module

Category

Functional

Function

ADC stops operating if ADC clock source is changed from SMCLK to another source while SMCLKOFF = 1.

Description

When SMCLK is used as the clock source for the ADC (ADC12CTL1.ADC12SSELx = 11) and CSCTL4.SMCLKOFF = 1, the ADC will stop operating if the ADC clock source is changed by user software (e.g. in the ISR) from SMCLK to a different clock source. This issue appears only for the ADC12CTL1.ADC12DIVx settings /3/5/7. The hang state can be recovered by PUC/POR/BOR/Power cycle.

Workaround

1. Set CSCTL4.SMCLKOFF = 0 before switch ADC clock source.

OR

2. Only use ADC12CTL1.ADC12DIVx as /1, /2, /4, /6, /8

CPU21

CPU Module

Category

Compiler-Fixed

Function

Using POPM instruction on Status register may result in device hang up

Description

When an active interrupt service request is pending and the POPM instruction is used to set the Status Register (SR) and initiate entry into a low power mode, the device may hang up.

Workaround None. It is recommended not to use POPM instruction on the Status Register.

Refer to the table below for compiler-specific fix implementation information.

IDE/Compiler	Version Number	Notes
IAR Embedded Workbench	Not affected	
TI MSP430 Compiler Tools (Code Composer Studio)	v4.0.x or later	User is required to add the compiler or assembler flag option below. --silicon_errata=CPU21
MSP430 GNU Compiler (MSP430-GCC)	MSP430-GCC 4.9 build 167 or later	

CPU22

CPU Module

Category Compiler-Fixed

Function Indirect addressing mode with the Program Counter as the source register may produce unexpected results

Description When using the indirect addressing mode in an instruction with the Program Counter (PC) as the source operand, the instruction that follows immediately does not get executed. For example in the code below, the ADD instruction does not get executed.

```
mov @PC, R7
add #1h, R4
```

Workaround Refer to the table below for compiler-specific fix implementation information.

IDE/Compiler	Version Number	Notes
IAR Embedded Workbench	Not affected	
TI MSP430 Compiler Tools (Code Composer Studio)	v4.0.x or later	User is required to add the compiler or assembler flag option below. --silicon_errata=CPU22
MSP430 GNU Compiler (MSP430-GCC)	MSP430-GCC 4.9 build 167 or later	

CPU40

CPU Module

Category Compiler-Fixed

Function PC is corrupted when executing jump/conditional jump instruction that is followed by instruction with PC as destination register or a data section

Description If the value at the memory location immediately following a jump/conditional jump instruction is 0X40h or 0X50h (where X = don't care), which could either be an instruction opcode (for instructions like RRCM, RRAM, RLAM, RRUM) with PC as destination register or a data section (const data in flash memory or data variable in RAM), then the PC value is auto-incremented by 2 after the jump instruction is executed; therefore, branching to a wrong address location in code and leading to wrong program execution.

For example, a conditional jump instruction followed by data section (0140h).

```
@0x8012 Loop DEC.W R6
@0x8014 DEC.W R7
@0x8016 JNZ Loop
@0x8018 Value1 DW 0140h
```

Workaround

In assembly, insert a NOP between the jump/conditional jump instruction and program code with instruction that contains PC as destination register or the data section.

Refer to the table below for compiler-specific fix implementation information.

IDE/Compiler	Version Number	Notes
IAR Embedded Workbench	IAR EW430 v5.51 or later	For the command line version add the following information Compiler: --hw_workaround=CPU40 Assembler:-v1
TI MSP430 Compiler Tools (Code Composer Studio)	v4.0.x or later	User is required to add the compiler or assembler flag option below. --silicon_errata=CPU40
MSP430 GNU Compiler (MSP430-GCC)	Not affected	

CPU46

CPU Module

Category

Functional

Function

POPM performs unexpected memory access and can cause VMAIFG to be set

Description

When the POPM assembly instruction is executed, the last Stack Pointer increment is followed by an unintended read access to the memory. If this read access is performed on vacant memory, the VMAIFG will be set and can trigger the corresponding interrupt (SFR1E1.VMAIE) if it is enabled. This issue occurs if the POPM assembly instruction is performed up to the top of the STACK.

Workaround

If the user is utilizing C, they will not be impacted by this issue. All TI/IAR/GCC pre-built libraries are not impacted by this bug. To ensure that POPM is never executed up to the memory border of the STACK when using assembly it is recommended to either

1. Initialize the SP to
 - a. TOP of STACK - 4 bytes if POPM.A is used
 - b. TOP of STACK - 2 bytes if POPM.W is used

OR

2. Use the POPM instruction for all but the last restore operation. For the the last restore operation use the POP assembly instruction instead.

For instance, instead of using:

```
POPM.W #5,R13
```

Use:

```
POPM.W #4,R12
POP.W R13
```

Refer to the table below for compiler-specific fix implementation information.

IDE/Compiler	Version Number	Notes
IAR Embedded Workbench	Not affected	C code is not impacted by this bug. User using POPM instruction in assembler is required to implement the above workaround manually.
TI MSP430 Compiler Tools (Code Composer Studio)	Not affected	C code is not impacted by this bug. User using POPM instruction in assembler is required to implement the above workaround manually.
MSP430 GNU Compiler (MSP430-GCC)	Not affected	C code is not impacted by this bug. User using POPM instruction in assembler is required to implement the above workaround manually.

CPU47***CPU Module*****Category**

Functional

Function

An unexpected Vacant Memory Access Flag (VMAIFG) can be triggered

Description

An unexpected Vacant Memory Access Flag (VMAIFG) can be triggered, if a PC-modifying instruction (e.g. - ret, push, call, pop, jmp, br) is fetched from the last addresses (last 4 or 8 byte) of a memory (e.g.- FLASH, RAM, FRAM) that is not contiguous to a higher, valid section on the memory map.

In debug mode using breakpoints the last 8 bytes are affected.

In free running mode the last 4 bytes are affected.

Workaround

Edit the linker command file to make the last 4 or 8 bytes of affected memory sections unavailable, to avoid PC-modifying instructions on these locations.

Remaining instructions or data can still be stored on these locations.

CS12***CS Module*****Category**

Functional

Function

DCO overshoot at frequency change

Description

When changing frequencies (CSCTL1.DCOFSEL), the DCO frequency may overshoot and exceed the datasheet specification. After a time period of 10us has elapsed, the frequency overshoot settles down to the expected range as specified in the datasheet.

The overshoot occur when switching to and from any DCOFSEL setting and impacts all peripherals using the DCO as a clock source. A potential impact can also be seen on FRAM accesses, since the overshoot may cause a temporary violation of FRAM access and cycle time requirements.

Workaround

When changing the DCO settings, use the following procedure:

- 1) Store the existing CSCTL3 divider into a temporary unsigned 16-bit variable
- 2) Set CSCTL3 to divide all corresponding clock sources by 4 or higher
- 3) Change DCO frequency
- 4) Wait ~10us
- 5) Restore the divider in CSCTL3 to the setting stored in the temporary variable.

The following code example shows how to increase DCO to 16MHz.

```
uint16_t tempCSCTL3 = 0;
CSCTL0_H = CSKEY_H; // Unlock CS registers
/* Assuming SMCLK and MCLK are sourced from DCO */
/* Store CSCTL3 settings to recover later */
tempCSCTL3 = CSCTL3;
/* Keep overshoot transient within specification by setting clk sources to
divide by 4 */
/* Clear the DIVS & DIVM masks (~0x77) and set both fields to 4 divider */
CSCTL3 = CSCTL3 & (~0x77) | DIVS_4 | DIVM_4;
CSCTL1 = DCOFSEL_4 | DCORSEL; // Set DCO to 16MHz
/* Delay by ~10us to let DCO settle. 60 cycles = 20 cycles buffer + (10us /
(1/4MHz)) */
__delay_cycles(60);
CSCTL3 = tempCSCTL3; // Set all dividers
CSCTL0_H = 0; // Lock CS registers
```

PMM31

PMM Module

Category

Functional

Function

Device may enter lockup state during transition from AM to LPM2/3/4

Description

The device might enter lockup state if the MODOSC is requested (e.g. triggered by ADC) or removed (e.g. end of ADC conversion) during a power mode transition from AM to LPM2/3/4 (e.g. during ISR exits or Status Register modifications).

The same behavior can appear when SMCLK is requested during a power mode transition from AM to LPM3/4.

The device will remain in a lockup state unable to respond to interrupts or continue application execution until a power cycle or external reset brings it back to reset state.

Modules which can trigger MODCLK clock requests/removals are ADC and eUSCI in I2C mode using the clock low timeout feature (e.g. SMBus, PMBus).

Modules which can trigger SMCLK clock requests are ADC, eUSCI in I2C Master mode, eUSCI in SPI Master mode and eUSCI in UART mode.

If clock requests are started by the CPU/DMA (e.g. eUSCI during SPI master transmission), they can't occur at the same time as the power mode transition and thus should not be affected. The device should only be affected when the clock request is asynchronous to the power mode transition.

Workaround

1. Avoid using the aforementioned combinations of clock requests and power mode transitions:

Use LPM0/1 instead of LPM2/3/4 when expecting asynchronous MODCLK requests and

removals.

OR

Use LPM0/1/2 instead of LPM3/4 when expecting asynchronous SMCLK requests.

OR

Use LPMx.5 instead of LPM2/3/4.

OR

Use a clock different than MODCLK/SMCLK when applicable (e.g. ACLK).

2. Prevent the power mode transition from happening when an asynchronous clock request/removal is expected:

Wake-up device before a UART byte is received.

AND

Wake-up device before an asynchronous ADC trigger and stay in Active Mode until conversion is completed.

AND

Keep device in AM/LPM0/LPM1 during ADC measurement.

PMM32

PMM Module

Category

Functional

Function

Device may enter lockup state or execute unintentional code during transition from AM to LPM2/3/4

Description

The device might enter lockup state or start executing unintentional code resulting in unpredictable behavior depending on the contents of the address location- if any of the two conditions below occurs:

Condition1:

The following three events happen at the same time:

1) The device transitions from AM to LPM2/3/4 (e.g. during ISR exits or Status Register modifications),

AND

2) An interrupt is requested (e.g. GPIO interrupt),

AND

3) MODCLK is requested (e.g. triggered by ADC) or removed (e.g. end of ADC conversion).

Modules which can trigger MODCLK clock requests/removals are ADC and eUSCI.

If clock events are started by the CPU (e.g. eUSCI during SPI master transmission), they can not occur at the same time as the power mode transition and thus should not be affected. The device should only be affected when the clock event is asynchronous to the power mode transition.

The device can recover from this lockup condition by a PUC/BOR/Power cycle (e.g. enable Watchdog to trigger PUC).

Condition2:

The following events happen at the same time:

1) The device transitions from AM to LPM2/3/4 (e.g. during ISR exits or Status Register modifications),

AND

2) An interrupt is requested (e.g. GPIO interrupt),

AND

3) Neither MODCLK nor SMCLK are running (e.g. requested by a peripheral),

AND

4) SMCLK is configured with a different frequency than MCLK.

The device can recover from this lockup condition by a BOR/Power cycle.

Workaround

1. Use LPM0/1/x.5 instead of LPM2/3/4.

OR

2. Place the FRAM in INACTIVE mode before any entry to LPM2/3/4 by clearing the FRPWR bit and FRLPMPWR bit (if exist) in the GCCTL0 register. This must be performed from RAM as shown below:

```
// define a function in RAM
#pragma CODE_SECTION(enterLpModeFromRAM, ".TI.ramfunc")
void enterLpModeFromRAM(unsigned short lowPowerMode);

//call this function before any entry to LPM2/3/4
void enterLpModeFromRAM(unsigned short lowPowerMode)
{
    FRCTL0 = FRCTLPW;
    GCCTL0 &= ~(FRPWR+FRLPMPWR); //clear FRPWR and FRLPMPWR
    FRCTL0_H = 0; //re-lock FRCTL
    __bis_SR_register(lowPowerMode);
}
```

RTC12

RTC Module

Category

Functional

Function

Real-time clock temperature compensation RTCTCOK bit not retained after LPM3.5 wake up

Description The RTC real-time clock temperature compensation write OK bit (RTCTCMP.RTCTCOK) is reset on wake up from LPM3.5 mode and does not get retained.

Workaround Store the RTCTCMP register content into FRAM for retention after wake up from LPM3.5

USCI42 *USCI Module*

Category Functional

Function UART asserts UCTXCPITIFG after each byte in multi-byte transmission

Description UCTXCPITIFG flag is triggered at the last stop bit of every UART byte transmission, independently of an empty buffer, when transmitting multiple byte sequences via UART. The erroneous UART behavior occurs with and without DMA transfer.

Workaround None.

USCI45 *USCI Module*

Category Functional

Function Unexpected SPI clock stretching possible when UCxCLK is asynchronous to MCLK

Description In rare cases, during SPI communication, the clock high phase of the first data bit may be stretched significantly. The SPI operation completes as expected with no data loss. This issue only occurs when the USCI SPI module clock (UCxCLK) is asynchronous to the system clock (MCLK).

Workaround Ensure that the USCI SPI module clock (UCxCLK) and the CPU clock (MCLK) are synchronous to each other.

USCI47 *USCI Module*

Category Functional

Function eUSCI SPI slave with clock phase UCCKPH = 1

Description The eUSCI SPI operates incorrectly under the following conditions:

1. The eUSCI_A or eUSCI_B module is configured as a SPI slave with clock phase mode UCCKPH = 1

AND

2. The SPI clock pin is not at the appropriate idle level (low for UCCKPL = 0, high for UCCKPL = 1) when the UCSWRST bit in the UCxxCTLW0 register is cleared.

If both of the above conditions are satisfied, then the following will occur:

eUSCI_A: the SPI will not be able to receive a byte (UCAxRXBUF will not be filled and UCRXIFG will not be set) and SPI slave output data will be wrong (first bit will be missed and data will be shifted).

eUSCI_B: the SPI receives data correctly but the SPI slave output data will be wrong (first byte will be duplicated or replaced by second byte).

Workaround Use clock phase mode UCCKPH = 0 for MSP SPI slave if allowed by the application.

OR

The SPI master must set the clock pin at the appropriate idle level (low for UCCKPL = 0, high for UCCKPL = 1) before SPI slave is reset (UCSWRST bit is cleared).

OR

For eUSCI_A: to detect communication failure condition where UCRXIFG is not set, check both UCRXIFG and UCTXIFG. If UCTXIFG is set twice but UCRXIFG is not set, reset the MSP SPI slave by setting and then clearing the UCSWRST bit, and inform the SPI master to resend the data.

USCI50

USCI Module

Category

Functional

Function

Data may not be transmitted correctly from the eUSCI when operating in SPI 4-pin master mode with UCSTEM = 0

Description

When the eUSCI is used in SPI 4-pin master mode with UCSTEM = 0 (STE pin used as an input to prevent conflicts with other SPI masters), data that is moved into UCxTXBUF while the UCxSTE input is in the inactive state may not be transmitted correctly. If the eUSCI is used with UCSTEM = 1 (STE pin used to output an enable signal), data is transmitted correctly.

Workaround

When using the STE pin in conflict prevention mode (UCSTEM = 0), only move data into UCxTXBUF when UCxSTE is in the active state. If an active transfer is aborted by UCxSTE transitioning to the master-inactive state, the data must be rewritten into UCxTXBUF to be transferred when UCxSTE transitions back to the master-active state.

7 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from January 22, 2019 to May 11, 2021	Page
<ul style="list-style-type: none"> Changed the document format and structure; updated the numbering format for tables, figures, and cross references throughout the document..... ZVW87 was updated..... 	 6 6

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