

# MSP430FR5868 Device Erratasheet

---



---



---

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

## 1 Functional Errata Revision History

Errata impacting device's operation, function or parametrics.

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

Errata Number	Rev H	Rev G	Rev F
<a href="#">ADC38</a>	✓	✓	✓
<a href="#">ADC41</a>	✓	✓	✓
<a href="#">ADC42</a>	✓	✓	✓
<a href="#">ADC43</a>	✓	✓	✓
<a href="#">ADC64</a>	✓	✓	✓
<a href="#">ADC66</a>	✓	✓	✓
<a href="#">ADC69</a>	✓	✓	✓
<a href="#">COMP7</a>	✓	✓	✓
<a href="#">COMP10</a>	✓	✓	✓
<a href="#">CPU46</a>	✓	✓	✓
<a href="#">CPU47</a>	✓	✓	✓
<a href="#">CS3</a>	✓	✓	✓
<a href="#">CS7</a>	✓	✓	✓
<a href="#">CS12</a>	✓	✓	✓
<a href="#">DMA7</a>	✓	✓	✓
<a href="#">DMA11</a>	✓	✓	✓
<a href="#">GC1</a>	✓	✓	✓
<a href="#">GC4</a>	✓	✓	✓
<a href="#">GC5</a>	✓	✓	✓
<a href="#">PMM24</a>		✓	✓
<a href="#">PMM31</a>	✓	✓	✓
<a href="#">PMM32</a>	✓	✓	✓
<a href="#">PMM33</a>	✓	✓	✓
<a href="#">PORT28</a>	✓	✓	✓
<a href="#">REF9</a>	✓	✓	✓
<a href="#">RTC10</a>	✓	✓	✓
<a href="#">USCI41</a>	✓	✓	✓
<a href="#">USCI42</a>	✓	✓	✓
<a href="#">USCI45</a>	✓	✓	✓
<a href="#">USCI47</a>	✓	✓	✓
<a href="#">USCI50</a>	✓	✓	✓
<a href="#">WDG5</a>	✓	✓	✓

## 2 Preprogrammed Software Errata Revision History

Errata impacting pre-programmed software into the silicon by Texas Instruments.

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

Errata Number	Rev H	Rev G	Rev F
<a href="#">ADC67</a>	✓	✓	✓

## 3 Debug only Errata Revision History

Errata only impacting debug operation.

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

Errata Number	Rev H	Rev G	Rev F
<a href="#">EEM19</a>	✓	✓	✓
<a href="#">EEM23</a>	✓	✓	✓
<a href="#">EEM27</a>	✓	✓	✓
<a href="#">EEM28</a>	✓	✓	✓
<a href="#">EEM30</a>	✓	✓	✓
<a href="#">EEM31</a>	✓	✓	✓
<a href="#">JTAG27</a>	✓	✓	✓

## 4 Fixed by Compiler Errata Revision History

Errata completely resolved by compiler workaround. Refer to specific erratum for IDE and compiler versions with workaround.

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

Errata Number	Rev H	Rev G	Rev F
<a href="#">CPU21</a>	✓	✓	✓
<a href="#">CPU22</a>	✓	✓	✓
<a href="#">CPU40</a>	✓	✓	✓

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 Package Markings

**RGZ48**
**QFN (RGZ), 48 Pin**

<div style="border: 1px solid black; padding: 5px; width: fit-content;"> <div style="display: flex; align-items: center; margin-bottom: 5px;"> <div style="margin-right: 10px;">○</div> <div>MSP430™</div> </div> <div style="margin-bottom: 5px;">FRxxxx</div> <div style="margin-bottom: 5px;">TI NNN #</div> <div>NNNN <u>G4</u></div> </div>	<div style="margin-bottom: 5px;"># = Die revision</div> <div style="margin-bottom: 5px;">○ = Pin 1 location</div> <div>N = Lot trace code</div>
--	---

## 6 Memory-Mapped Hardware Revision (TLV Structure)

Die Revision	TLV Hardware Revision
Rev H	40h
Rev G	31h
Rev F	30h

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

## 7 Detailed Bug Description

<b>ADC38</b>	<b><i>ADC12_B Module</i></b>
<b>Category</b>	Functional
<b>Function</b>	External ADC trigger without toggling ENC bit might prevent further ADC conversions.
<b>Description</b>	<p>The ADC may stop sampling and converting until the module is reset if an external (timer) trigger occurs without toggling the ADC12CTL0.ADC12ENC bit at:</p> <ul style="list-style-type: none"> <li>- The end of sequence in the sequence-of-channel mode.</li> <li>- The end of conversion in single-channel mode.</li> </ul>
<b>Workaround</b>	Ensure ADC12CTL0.ADC12ENC bit is always toggled before providing any new External Trigger to ADC.
<b>ADC41</b>	<b><i>ADC12_B Module</i></b>
<b>Category</b>	Functional
<b>Function</b>	ADC conversion only triggers when sourced from TA0 and TA3 in LPM3/LPM4
<b>Description</b>	If the ADC clock is sourced from ADC12OSC (ADC12CTL1.ADC12SSELx = ADC12OSC), the reference module is not used (REFCTL0.REFON = 0), and the device is in LPM3/LPM4 mode, ADC conversion cannot be triggered when using Timer TB0, TA1 and TA2 (ADC12CTL1.ADC12SHSx).
<b>Workaround</b>	<ol style="list-style-type: none"> <li>1. Use Timer TA0 or TA3 to trigger ADC conversion in LPM3/LPM4 mode</li> </ol> OR <ol style="list-style-type: none"> <li>2. Configure ADC clock to be sourced from ACLK (ADC12CTL1.ADC12SSELx = ACLK).</li> </ol> OR <ol style="list-style-type: none"> <li>3. Use Active/LPM0/LPM1/LPM2 mode</li> </ol> OR <ol style="list-style-type: none"> <li>4. Use the internal voltage reference (REFCTL0.REFON = 1)</li> </ol>
<b>ADC42</b>	<b><i>ADC12_B Module</i></b>
<b>Category</b>	Functional
<b>Function</b>	ADC stops converting when successive ADC is triggered before the previous conversion ends
<b>Description</b>	<p>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:</p> <ul style="list-style-type: none"> <li>- sequence-of-channels</li> <li>- repeat-single-channel</li> <li>- repeat-sequence-of-channels (ADC12CTL1.ADC12CONSEQx)</li> </ul> <p>In addition, the timer overflow flag cannot be used to detect an overflow (ADC12IFGR2.ADC12TOVIFG).</p>
<b>Workaround</b>	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

## **ADC43**

### ***ADC12\_B Module***

#### **Category**

Functional

#### **Function**

DMA does not trigger at the end of an ADC12 sequence of channels

#### **Description**

The DMA transfer is triggered at the end of every ADC conversion when the ADC is configured to convert in a sequence of channels (ADC12CTL1.CONSEQ = 1 or 3.) This causes the DMA transfer to trigger prematurely after each ADC conversion instead of triggering only at the end of the conversion sequence.

#### **Workaround**

Design the application to expect the DMA trigger at the end of every ADC conversion. For example, if a block transfer at the end of the sequence is originally desired, configure the DMA in single transfer mode with size = length of the sequence. The DMA transfer occurs at each conversion, but the DMA interrupt will still occur at the end of the sequence.

## **ADC64**

### ***ADC12\_B Module***

#### **Category**

Functional

#### **Function**

Incorrect conversion result in extended sample mode in some conditions

#### **Description**

The ADC12 conversion result can be incorrect if the extended sample mode is selected (ADC12SHP = 0), ADC12VRSEL is set to 0, 2, 4, 6, 12, 14 (VR+ and VR- unbuffered), and the ADC sample time is less than 6 ADC clock cycles.

#### **Workaround**

- 1) Use Pulse sample mode (ADC12SHP=1) if sample time less than 6 ADC clock cycles is needed;
- OR
- 2) In extended sample mode (ADC12SHP = 0) increase the sample time to at least 6 ADC clock cycles;
- OR
- 3) Use reference mode corresponding to ADC12VRSEL =1,3,5,7,9,13,15

## **ADC66**

### ***ADC12\_B Module***

#### **Category**

Functional

#### **Function**

ADC stops converting when ADC12ON bit is toggled during conversion

#### **Description**

Subsequent ADC conversions are halted if the ADC12CTL0.ADC12ON bit is toggled while the ADC is busy. The affected ADC modes are:

- sequence-of-channels

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

**Workaround** Stop the ADC conversion by clearing the ADC12CTL0.ADC12ENC bit.  
Check the ADC12CTL1.ADC12BUSY flag for 0 before toggling the ADC12CTL0.ADC12ON bit.

### **ADC67** *ADC12\_B 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 > 88XXXXX 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** *ADC12\_B 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

### **COMP7** *COMP\_E Module*

---

**Category** Functional

**Function** Comparator triggers false output at low overdrive levels

**Description** When the differential voltage on the comparator input pins is smaller than the comparator offset according to the datasheet, the comparator can provide a false output.

**Workaround** Drive the differential voltage to above the comparator offset according to the datasheet.

### **COMP10** *COMP\_E Module*

---

**Category** Functional

**Function** Comparator port output toggles when entering or leaving LPM3/LPM4

**Description** The comparator port pin output (CECTL1.CEOUT) erroneously toggles when device enters or leaves LPM3/LPM4 modes under the following conditions:

- 1) Comparator is disabled (CECTL1.CEON = 0)  
AND
- 2) Output polarity is enabled (CECTL1.CEOUTPOL = 1)  
AND
- 3) The port pin is configured to have CEOUT functionality.

For example, if the CEOUT pin is high when the device is in Active Mode, CEOUT pin becomes low when the device enters LPM3/LPM4 modes.

**Workaround** When the comparator is disabled, ensure at least one of the following:

- 1) Output inversion is disabled (CECTL.CEOUTPOL = 0)  
OR
- 2) Change pin configuration from CEOUT to GPIO with output low.

## **CPU21** ***CPUXv2 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** ***CPUXv2 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

### *CPUXv2 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

### *CPUXv2 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 (SFRIF1.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**
**CPUXv2 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.

**CS3**
**CS Module**


---

**Category**

Functional

**Function**

Possible PMM overload when increasing SMCLK frequency to higher than MCLK frequency

**Description**

When switching SMCLK frequency from lower to higher than MCLK frequency, the device can crash and hang until it is restarted by a reset.

**Workaround**

1.
  - a. Increase SMCLK to MCLK frequency to ensure they are the same
  - b. Then, increase SMCLK frequency to target frequency
- OR
2.
  - a. Increase MCLK frequency to the desired SMCLK frequency
  - b. Then, increase SMCLK to target frequency
  - c. Then, decrease MCLK back to the original MCLK frequency

**CS7**
**CS Module**


---

**Category**

Functional

**Function**

DCO clock frequency out of specification when returning from LPM2, LPM3 or LPM4

**Description**

When waking up from LPM2, LPM3 or LPM4 the first clocks generated by the DCO are not within the specified frequency range for approximately 13us (independent of the selected frequency). Any observable overshoot of the frequency is not critical for the device functionality. Frequency undershoots can be considered as additional wake-up delay because the frequency is below the target and less clocks are generated than expected. The overall impact of the clock overshoots and undershoots during stabilization is approximately 2us of additional delay.

**Workaround**

Account for frequency undershoots as additional wake-up delay of about 2us.

**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
```

## DMA7

### *DMA Module*

#### Category

Functional

#### Function

DMA request may cause the loss of interrupts

#### Description

If a DMA request starts executing during the time when a module register containing an interrupt flags is accessed with a read-modify-write instruction, a newly arriving interrupt from the same module can get lost. An interrupt flag set prior to DMA execution would not be affected and remain set.

#### Workaround

1. Use a read of Interrupt Vector registers to clear interrupt flags and do not use read-modify-write instruction.

OR

2. Disable all DMA channels during read-modify-write instruction of specific module registers containing interrupts flags while these interrupts are activated.

## DMA11

### *DMA Module*

#### Category

Functional

#### Function

DMA trigger during transition into LPM1/LPM2/LPM3/LPM4 may cause the device to reset

#### Description

The device performs a PUC if the DMA is triggered while the system transitions the power mode from active to LPM1/LPM2/LPM3/LPM4. The susceptible time window at power mode transition is 1 MCLK cycle + 500ns.

#### Workaround

Ensure that the DMA is not triggered during active mode to LPM1/LPM2/LPM3/LPM4 transition.

1. Perform a software DMA trigger inside a module interrupt service routine instead of using the modules DMA trigger.

OR

2. Use Active Mode or LPM0 when using DMA.

**EEM19**
***EEM Module***


---

**Category**

Debug

**Function**

DMA may corrupt data in debug mode

**Description**

When the DMA is enabled and the device is in debug mode, the data written by the DMA may be corrupted when a breakpoint is hit or when the debug session is halted.

**Workaround**

This erratum has been addressed in MSPDebugStack version 3.5.0.1. It is also available in released IDE EW430 IAR version 6.30.3 and CCS version 6.1.1 or newer.

If using an earlier version of either IDE or MSPDebugStack, do not halt or use breakpoints during a DMA transfer.

---

**NOTE:** This erratum applies to debug mode only.

---

**EEM23**
***EEM Module***


---

**Category**

Debug

**Function**

EEM triggers incorrectly when modules using wait states are enabled

**Description**

When modules using wait states (USB, MPY, CRC and FRAM controller in manual mode) are enabled, the EEM may trigger incorrectly. This can lead to an incorrect profile counter value or cause issues with the EEMs data watch point, state storage, and breakpoint functionality.

**Workaround**

None.

---

**NOTE:** This erratum affects debug mode only.

---

**EEM27**
***EEM Module***


---

**Category**

Debug

**Function**

Switching off FRAM LDO stalls device during debug access

**Description**

With the "Enable Ultra Low Power debug/LPMx.5 debug" option disabled in the IDE, if user application switches off the FRAM LDO (FRPWR = 0) and a debug halt is requested during this time, device debug control is lost and the debug session must be restarted. At this point, the code execution is also stalled.

The following error message is observed:

IAR - "Internal error: (State)"

CCS - "MSP430: Trouble Halting Target CPU: Internal error"

**Workaround**

If IDE error message is observed, restart the debug session or perform a hardware reset. Turn on "Enable Ultra Low Power debug/LPMx.5 debug" option in the IDE debug settings.

<b>EEM28</b>	<b><i>EEM Module</i></b>
<b>Category</b>	Debug
<b>Function</b>	Clock outputs observed on port module during LPMx in debug mode
<b>Description</b>	<p>When the device is in LPMx mode, if a debug halt is requested and if the port pin is configured as MCLK, SMCLK, or ACLK output, these clocks are observed on the port pin. Depending on the LPM mode (see Device User's Guide), peripherals that are clocked from MCLK, SMCLK, or ACLK are still halted during debug halt state.</p> <p>For example, if the device is in debug halt in LPM3 mode and a port pin is configured as SMCLK output, SMCLK can be observed on the pin. But the peripherals sourced from SMCLK are still halted as expected.</p>
<b>Workaround</b>	None
<b>EEM30</b>	<b><i>EEM Module</i></b>
<b>Category</b>	Debug
<b>Function</b>	Missed breakpoint if FRAM power supply is disabled
<b>Description</b>	The FRAM power supply can be disabled (GCCTL0.FRPWR = 0) prior to LPM entry to save power. Upon wakeup, if a breakpoint is set on an the first instruction that accesses FRAM, the breakpoint may be missed.
<b>Workaround</b>	None. This issue affects debug mode only.
<b>EEM31</b>	<b><i>EEM Module</i></b>
<b>Category</b>	Debug
<b>Function</b>	Breakpoint trigger may be lost when MPU is enabled
<b>Description</b>	A data value written to FRAM can be used as a trigger condition for breakpoints during a debug session. This trigger can be lost if the FRAM access is made to an address that has been write-protected by the MPU.
<b>Workaround</b>	None. This issue affects debug mode only.
<b>GC1</b>	<b><i>GC Module</i></b>
<b>Category</b>	Functional
<b>Function</b>	Uncorrectable memory bit error flag (GCCTL1.UBDIFG) does not trigger NMI
<b>Description</b>	The GCCTL1.UBDIFG flag is an interrupt flag that gets set if an uncorrectable bit error has been detected in non-volatile memory. Even the GCCTL1.UBDIFG flag is set to 1 (GCCTL0.UBDRSTEN = 0 and GCCTL0.UBDIE = 1), it does not trigger a NMI request. In this case, the application is not notified via a NMI request that an uncorrectable bit error occurred in non-volatile memory (SYSSNIV = 0).
<b>Workaround</b>	<p>Set GCCTL0.UBDRSTEN = 1 and GCCTL0.UBDIE = 0 to trigger a PUC and check GCCTL1.UBDIFG = 1 after each PUC for manual interrupt flag handling.</p> <p>Please consider GC4 errata for side effects.</p>

<b>GC4</b>	<b>GC Module</b>
<b>Category</b>	Functional
<b>Function</b>	Unexpected PUC is triggered
<b>Description</b>	<p>During execution from FRAM a non-existent uncorrectable bit error can be detected and trigger a PUC if the uncorrectable bit error detection flag is set (GCCTL0.UBDRSTEN = 1). This behavior appears only if:</p> <p>(1) MCLK is sourced from DCO frequency of 16 MHz OR (2) MCLK is sourced by external high frequency clock above 12 MHz at pin HFXIN OR (3) MCLK is sourced by High-Frequency crystals (HFXT) above 12 MHz.</p> <p>This PUC will not be recognized by the SYSRSTIV register (SYSRSTIV = 0x00). A PUC RESET will be executed with not defined reset source. Also the corresponding bit error detection flag is not set (GCCTL1.UBDIFG = 0).</p>
<b>Workaround</b>	<ol style="list-style-type: none"> <li>1. Check the reset source for SYSRSTIV = 0 and ignore the reset. OR</li> <li>2. Set GCCTL0.UBDRSTEN = 0 to prevent unexpected PUC. NMI event will not be triggered, even if GCCTL0.UBDIE = 1 -&gt; consider GC1 Errata for more details. OR</li> <li>3. Set the MCLK to maximum 12MHz to leverage the uncorrectable bit error PUC feature.</li> </ol>
<b>GC5</b>	<b>GC Module</b>
<b>Category</b>	Functional
<b>Function</b>	Nonexistent FRAM failures can be detected after wake-up from LPM 1/2/3/4
<b>Description</b>	<p>The FRAM bit error detection may indicate bit errors, even the memory has no failure, after wakeup from LPM1/2/3/4.</p> <p>Based on the setting inside the FRAM controller registers (GCCTL0), following behaviors can appear.</p> <ol style="list-style-type: none"> <li>1. Unexpected PUC for an uncorrectable FRAM error can be triggered and causing the corresponding value in the SYSRSTIV register. This happens only if GCCTL0.UBDRSTEN =1.</li> <li>2. Unexpected NMI for an uncorrectable FRAM error can be triggered and causing the corresponding value in the SYSSNIV register. This happens only if the GCCTL0.UBDIE = 1.</li> <li>3. Unexpected NMI for a correctable FRAM error can be triggered and causing the corresponding value in the SYSSNIV register. This happens only if the GCCTL0.CBDIE =1.</li> </ol>
<b>Workaround</b>	<ol style="list-style-type: none"> <li>1. Disable PUC (GCCTL0.UBDRSTEN=0), UBDIE and CBDIE interrupts (GCCTL0.UBDIE=0 and GCCTL0.CBDIE=0) prior to entering LPM 1/2/3/4.</li> </ol>

2. After LPM wake up, clear GCCTL1.UBDIFG and GCCTL1.CBDIFG, and then reinitialize the GCCTL0 register after the first valid FRAM access has been completed. For the valid FRAM access the user has to consider possible cache hits which depends on implementation.

## JTAG27

### *JTAG Module*

---

**Category**

Debug

**Function**

Unintentional code execution after programming via JTAG/SBW

**Description**

The device can unintentionally start executing code from uninitialized RAM addresses 0x0006 or 0x0008 after being programming via the JTAG or SBW interface. This can result in unpredictable behavior depending on the contents of the address location.

**Workaround**

1. If using programming tools purchased from TI (MSP-FET, LaunchPad), update to CCS version 6.1.3 later or IAR version 6.30 or later to resolve the issue.
2. If using the MSP-GANG Production Programmer, use v1.2.3.0 or later.
3. For custom programming solutions refer to the specification on MSP430 Programming Via the JTAG Interface User's Guide (SLAU320) revision V or newer and use MSPDebugStack v3.7.0.12 or later.

For MSPDebugStack (MSP430.DLL) in CCS or IAR, download the latest version of the development environment or the latest version of the [MSPDebugStack](#)

NOTE: This only affects debug mode.

## PMM24

### *PMM Module*

---

**Category**

Functional

**Function**

Device may enter lockup state during wake-up from LPM3 and LPM4

**Description**

The device may enter a lockup state during an interrupt-triggered wake up from LPM3 or LPM4. The device will remain in lockup state, unable to respond to the interrupt or continue application execution, until a power cycle brings it back to reset state.

LPM3.5 and LPM4.5 are not affected by this behavior.

**Workaround**

- 1) Use LPM2 instead of LPM3 or LPM4. Refer to the device specific datasheet for details on LPM2 wake up time and power consumption.

OR

- 2) If the application only uses RTC or GPIO as a wakeup source, use LPM3.5 or LPM4.5 instead. Refer to the device specific datasheet for details on LPM3.5/LPM4.5 wake up times and power consumption.

Note: When using LPM3.5/LPM4.5, the Compute Through Power Loss (CTPL) utility APIs (part of the [FRAM software utilities](#)) can be used to configure device behavior prior to LPM entry and on wake-up.

## 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);
}
```

<b>PMM33</b>	<b><i>PMM Module</i></b>
<b>Category</b>	Functional
<b>Function</b>	Device might hang-up or generate a RESET during LPM3 wake-up
<b>Description</b>	<p>If the device is used in LPM3 and peripherals of only one of the below peripheral groups (see also table 6-3 in datasheet under chapter 6.3.1.1) are used (only A or only B), the device might hang-up during wake-up or cause an unexpected reset (BOR or ACCTEIFG).</p> <p>GroupA:</p> <ul style="list-style-type: none"> <li>- TimerTA1</li> <li>- TimerTA2</li> <li>- TimerTB0</li> <li>- eUSCI_A0</li> <li>- eUSCI_A1</li> <li>- eUSCI_B0</li> </ul> <p>GroupB:</p> <ul style="list-style-type: none"> <li>- TimerTA0</li> <li>- TimerTA3</li> <li>- Comparator</li> <li>- ADC12_B</li> <li>- REF_A</li> </ul>
<b>Workaround</b>	<ol style="list-style-type: none"> <li>1. Use AM, LPM0, LPM1 or LPM2 instead of LPM3</li> </ol> <p>or</p> <ol style="list-style-type: none"> <li>2. Use LPM3 with <ol style="list-style-type: none"> <li>a. no other peripherals except WDT and RTC are used in LPM3</li> </ol> </li> </ol> <p>or</p> <ol style="list-style-type: none"> <li>b. at least one peripheral from each peripheral group (A and B) is enabled in LPM3</li> </ol>
<b>PORT28</b>	<b><i>PORT Module</i></b>
<b>Category</b>	Functional
<b>Function</b>	Pull-down resistor of TEST/SBWTCK pin
<b>Description</b>	The device's internal pull-down resistor on the TEST/SBWTCK pin gets disabled if the SYS control bit SFRRPCR.SYSRSTRE is cleared. This can lead to increased current consumption and unintentionally-enabled JTAG access to the device.
<b>Workaround</b>	<ol style="list-style-type: none"> <li>1) Do not clear the SFRRPCR.SYSRSTRE bit, use the SFRRPCR.SYSRSTRUP bit to define direction of the internal resistor on RST/NMI/SBWTDIO pin instead.</li> </ol> <p>OR</p> <ol style="list-style-type: none"> <li>2) Ensure a zero voltage level of TEST/SBWTCK pin by connecting the pin to an external component (e.g. external pull-down resistor) on the PCB.</li> </ol>

<b>REF9</b>	<b><i>REF_A Module</i></b>
<b>Category</b>	Functional
<b>Function</b>	REFON Feature
<b>Description</b>	The Reference module does not provide REF voltage to Comparator module when the REFON bit is set (REFCTL0.REFON=1).
<b>Workaround</b>	<ol style="list-style-type: none"> <li>1. Use REFBGOT bit of the REFCTL0 register instead of REFON bit to provide REF voltage to Comparator.</li> </ol> <p>OR</p> <ol style="list-style-type: none"> <li>2. Enable the Comparator module with internal REF setting (CEREFL + CERS bits of the CECTL2 register) to request the REF module.</li> </ol>
<b>RTC10</b>	<b><i>RTC_B Module</i></b>
<b>Category</b>	Functional
<b>Function</b>	RTC interrupt flag can be lost during LPMx.5 entry
<b>Description</b>	An RTC interrupt flag can get lost if it triggers within a small critical time window of the device's entry into LPM3.5. This results in the RTC interrupt flag not triggering a wake-up from LPM3.5. The subsequent RTC interrupt flag is captured to wake device up from LPM3.5.
<b>Workaround</b>	Use LPM3 for timing-critical applications where the device is entering LPM3.5 close to the RTC interrupt flag triggering.
<b>USCI41</b>	<b><i>eUSCI Module</i></b>
<b>Category</b>	Functional
<b>Function</b>	UCBUSY bit of eUSCIA module might not work reliable when device is in SPI mode.
<b>Description</b>	When eUSCIA is configured in SPI mode, the UCBUSY bit might get stuck to 1 or start toggling after transmission is completed. This happens in all four combinations of Clock Phase and Clock Polarity options (UCAxCTLW0.UCCKPH & UCAxCTLW0.UCCKPL bits) as well as in Master and Slave mode. There is no data loss or corruption. However the UCBUSY cannot be used in its intended function to check if transmission is completed. Because the UCBUSY bit is stuck to 1 or toggles, the clock request stays enabled and this adds additional current consumption in low power mode operation.
<b>Workaround</b>	<p>For correct functional implementation check on transmit or receive interrupt flag UCTXIFG/UCRXIFG instead of UCBUSY to know if the UCAxTXBUF buffer is empty or ready for the next complete character.</p> <p>To reduce the additional current it is recommended to either reset the SPI module (UCAxCTLW0.UCSWRST) in the UCBxCTLW0 or send a dummy byte 0x00 after the intended SPI transmission is completed.</p>
<b>USCI42</b>	<b><i>eUSCI Module</i></b>
<b>Category</b>	Functional
<b>Function</b>	UART asserts UCTXCPITFG after each byte in multi-byte transmission

<b>Description</b>	UCTXCPTIFG 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.
<b>Workaround</b>	None.
<hr/>	
<b>USCI45</b>	<b><i>eUSCI Module</i></b>
<b>Category</b>	Functional
<b>Function</b>	Unexpected SPI clock stretching possible when UCxCLK is asynchronous to MCLK
<b>Description</b>	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).
<b>Workaround</b>	Ensure that the USCI SPI module clock (UCxCLK) and the CPU clock (MCLK) are synchronous to each other.
<hr/>	
<b>USCI47</b>	<b><i>eUSCI Module</i></b>
<b>Category</b>	Functional
<b>Function</b>	eUSCI SPI slave with clock phase UCCKPH = 1
<b>Description</b>	<p>The eUSCI SPI operates incorrectly under the following conditions:</p> <ol style="list-style-type: none"> <li>1. The eUSCI_A or eUSCI_B module is configured as a SPI slave with clock phase mode UCCKPH = 1</li> </ol> <p>AND</p> <ol style="list-style-type: none"> <li>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.</li> </ol> <p>If both of the above conditions are satisfied, then the following will occur:</p> <p>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).</p> <p>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).</p>
<b>Workaround</b>	<p>Use clock phase mode UCCKPH = 0 for MSP SPI slave if allowed by the application.</p> <p>OR</p> <p>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).</p> <p>OR</p> <p>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.</p>
<hr/>	
<b>USCI50</b>	<b><i>eUSCI Module</i></b>
<b>Category</b>	Functional
<b>Function</b>	Data may not be transmitted correctly from the eUSCI when operating in SPI 4-pin

master mode with UCSTEM = 0

<b>Description</b>	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.
<b>Workaround</b>	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.

## **WDG5**

### ***WDT\_A Module***

<b>Category</b>	Functional
<b>Function</b>	Clock Fail-Safe feature in LPMx.5
<b>Description</b>	The watchdog clock fail-safe feature does not prevent the device from going into LPMx.5. As a result, the device enters LPMx.5 state independently of running the watchdog. Note that the watchdog is off in LPMx.5.
<b>Workaround</b>	None.

## 8 Document Revision History

Changes from device specific erratasheet to document Revision A.

1. Errata CS7 was added to the errata documentation.
2. Errata RTC10 was added to the errata documentation.

Changes from document Revision A to Revision B.

1. Errata DMA7 was added to the errata documentation.
2. Errata CPU43 was removed from the errata documentation.
3. Silicon Revision G was added to the errata documentation.

Changes from document Revision B to Revision C.

1. DMA7 Workaround was updated.
2. EEM23 Description was updated.
3. DMA7 Description was updated.

Changes from document Revision C to Revision D.

1. ADC38 Function was updated.
2. ADC38 Description was updated.
3. ADC38 Workaround was updated.

Changes from document Revision D to Revision E.

1. Errata USCI41 was added to the errata documentation.

Changes from document Revision E to Revision F.

1. Errata PMM24 was added to the errata documentation.

Changes from document Revision F to Revision G.

1. Errata PORT28 was added to the errata documentation.

Changes from document Revision G to Revision H.

1. EEM19 Workaround was updated.
2. Errata REF9 was added to the errata documentation.

Changes from document Revision H to Revision I.

1. Errata CS12 was added to the errata documentation.
2. Errata USCI42 was added to the errata documentation.
3. Errata EEM30 was added to the errata documentation.
4. Errata EEM31 was added to the errata documentation.
5. Errata JTAG27 was added to the errata documentation.
6. Errata COMP10 was added to the errata documentation.

Changes from document Revision I to Revision J.

1. Silicon Revision H was added to the errata documentation.
2. Errata CPU46 was added to the errata documentation.

Changes from document Revision J to Revision K.

1. CPU21 was added to the errata documentation.
2. CPU22 was added to the errata documentation.
3. USCI45 was added to the errata documentation.
4. Workaround for RTC10 was updated.
5. Workaround for CPU40 was updated.
6. Workaround for CPU46 was updated.
7. Description for USCI41 was updated.

Changes from document Revision K to Revision L.

1. ADC64 was added to the errata documentation.
2. TLV hardware revision ID for Rev H was updated.
3. Workaround for CPU46 was updated.

Changes from document Revision L to Revision M.

1. USCI47 was added to the errata documentation.

Changes from document Revision M to Revision N.

1. Function for USCI47 was updated.
2. Description for USCI47 was updated.
3. Workaround for USCI47 was updated.

Changes from document Revision N to Revision O.

1. Workaround for USCI47 was updated.

Changes from document Revision O to Revision P.

1. USCI50 was added to the errata documentation.
2. ADC66 was added to the errata documentation.
3. Function for USCI45 was updated.

Changes from document Revision P to Revision Q.

1. Erratasheet format update.
2. Added errata category field to "Detailed bug description" section

Changes from document Revision Q to Revision R.

1. PMM31 was added to the errata documentation.
2. Workaround for CPU40 was updated.

Changes from document Revision R to Revision S.

1. GC4 was added to the errata documentation.
2. ADC67 was added to the errata documentation.
3. Description for GC1 was updated.
4. Workaround for GC1 was updated.

Changes from document Revision S to Revision T.

1. PMM32 was added to the errata documentation.

Changes from document Revision T to Revision U.

1. GC5 was added to the errata documentation.
2. CPU47 was added to the errata documentation.
3. ADC69 was added to the errata documentation.

Changes from document Revision U to Revision V.

1. Function for USCI41 was updated.
2. Description for USCI41 was updated.
3. Workaround for USCI41 was updated.

Changes from document Revision V to Revision W.

1. Workaround for GC5 was updated.

Changes from document Revision W to Revision X.

1. PMM33 was added to the errata documentation.

## IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, or other requirements. These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to TI's Terms of Sale ([www.ti.com/legal/termsofsale.html](http://www.ti.com/legal/termsofsale.html)) or other applicable terms available either on [ti.com](http://ti.com) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2020, Texas Instruments Incorporated