



New VLE Instructions for Improving Interrupt Handler Efficiency

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1 Introduction

The VLE instruction set provides a mixture of 16 and 32-bit instructions that are used in the Qorivva MPC55xx, MPC551x and MPC56xx, product families. This engineering bulletin details new VLE instructions that have been implemented to improve the efficiency of handling interrupts.

These new instructions allow groups of volatile registers to be saved to or restored from the stack using a single instruction. These instructions allow for simpler coding within the interrupt handler, in some cases, quicker context save, and restore times.

Contents

| | | |
|------|--------------------------------------|----|
| 1 | Introduction | 1 |
| 2 | Devices Affected by New Instructions | 2 |
| 3 | Instruction Operation Codes | 2 |
| 4 | Instruction Descriptions | 3 |
| 5 | Instruction Listings | 5 |
| 5.1 | Load Multiple Volatile GPR Word | 5 |
| 5.2 | Store Multiple Volatile GPR Word | 5 |
| 5.3 | Load Multiple Volatile SPR Word | 6 |
| 5.4 | Store Multiple Volatile SPR Word | 7 |
| 5.5 | Load Multiple Volatile SRR Word | 7 |
| 5.6 | Store Multiple Volatile SRR Word | 8 |
| 5.7 | Load Multiple Volatile CSRR Word | 8 |
| 5.8 | Store Multiple Volatile CSRR Word | 9 |
| 5.9 | Load Multiple Volatile DSRR Word | 9 |
| 5.10 | Store Multiple Volatile DSRR Word | 10 |
| 6 | Revision history | 10 |

2 Devices Affected by New Instructions

All devices that implement the e200z1 and e200z0 cores support these new instructions in the VLE instruction set.

These instructions are currently implemented on the following devices. See [Table 1](#).

Table 1. Devices Supporting New Instructions

| Device | Core | New VLE Instruction Support |
|----------|-------------------|-----------------------------|
| MPC51xx | e200z1 and e200z0 | Yes |
| MPC563xM | e200z335 | Yes |
| MPC560xB | e200z0 | Yes |
| MPC560xP | e200z0 | Yes |
| MPC560xS | e200z0 | Yes |

3 Instruction Operation Codes

The operation codes of the additional instructions are listed in [Table 2](#).

Table 2. Operation Codes of New Instructions

| Instruction Bit Coding | 0.....5 | 6.....10 | 11.....15 | 16.....23 | 24.....31 |
|------------------------|---------------|----------|-----------|-------------|-----------|
| e_ldmvgprw | 6 (0b0001_10) | 0b00000 | RA | 0b0001_0000 | D8 |
| e_stmvgprw | 6 (0b0001_10) | 0b00000 | RA | 0b0001_0001 | D8 |
| e_ldmvsprw | 6 (0b0001_10) | 0b00001 | RA | 0b0001_0000 | D8 |
| e_stmvsprw | 6 (0b0001_10) | 0b00001 | RA | 0b0001_0001 | D8 |
| e_ldmvsrrw | 6 (0b0001_10) | 0b00100 | RA | 0b0001_0000 | D8 |
| e_stmvsrrw | 6 (0b0001_10) | 0b00100 | RA | 0b0001_0001 | D8 |
| e_ldmvsrww | 6 (0b0001_10) | 0b00101 | RA | 0b0001_0000 | D8 |
| e_stmvsrww | 6 (0b0001_10) | 0b00101 | RA | 0b0001_0001 | D8 |
| e_ldmvsrrw | 6 (0b0001_10) | 0b00110 | RA | 0b0001_0000 | D8 |
| e_stmvsrrw | 6 (0b0001_10) | 0b00110 | RA | 0b0001_0001 | D8 |

NOTE

The 8-bit D8 field is sign-extended and added to the contents of the GPR designated by RA to produce the effective load or store address.

4 Instruction Descriptions

The embedded application binary interface (EABI) defines specific registers to be classified as volatile and non-volatile registers. These registers are shown in [Table 3](#).

Table 3. EABI Register Definitions

| | | | | | |
|----------------|---------------------------|--------------|---------|-------------------------------|--------------|
| r0 | function linkage | volatile | r31 | local variables / env pointer | non-volatile |
| r1 | stack frame pointer | dedicated | cr0-cr1 | condition reg. fields | volatile |
| r2 | small data area 2 pointer | dedicated | cr2-cr4 | condition reg. fields | non-volatile |
| r3-r4 | parameters/return values | volatile | cr5-cr7 | condition reg. fields | volatile |
| r5-r10 | parameters | volatile | lr | link register | volatile |
| r11-r12 | function linkage | volatile | ctr | count register | volatile |
| r13 | small data area pointer | dedicated | xer | integer exception reg. | volatile |
| r14-r30 | local variables | non-volatile | | | |

Using a typical VLE interrupt handler, the volatile registers are saved and restored from the stack using store and load instructions for each individual register. This is shown in [Figure 1](#).

```

mFSRR1 r0                # Store SRR1 (must be done before enabling EE)
e_stw  r0, 0x10 (r1)
mFSRR0 r0                # Store SRR0 (must be done before enabling EE)
e_stw  r0, 0x0C (r1)
mFLR  r0                 # Store LR (Store now since LR will be
                        # used for ISR Vector)
wrteei 1                 # Set MSR[EE]=1

e_stw  r12, 0x4C (r1)    # Store GPRs
e_stw  r11, 0x48 (r1)
e_stw  r10, 0x44 (r1)
e_stw  r9, 0x40 (r1)
e_stw  r8, 0x3C (r1)
e_stw  r7, 0x38 (r1)
e_stw  r6, 0x34 (r1)
e_stw  r5, 0x30 (r1)
e_stw  r4, 0x2C (r1)
e_stw  r3, 0x28 (r1)
e_stw  r0, 0x24 (r1)

mFCR  r0                 # Store CR
e_stw  r0, 0x20 (r1)
mFXER r0                 # Store XER
e_stw  r0, 0x1C (r1)
mFCTR r0                 # Store CTR
e_stw  r0, 0x18 (r1)
    
```

Figure 1. Interrupt Handler Prolog

Instruction Descriptions

The new VLE instructions allow groups of volatile registers to be saved and restored to the stack using a single instruction. This reduces the number of instructions required and the time taken to save or restore all the volatile registers. [Table 4](#) describes how the new VLE instructions relate to the groups of volatile registers.

Table 4. Instruction Overview

| Instruction | Description | Registers Written / Read |
|-------------|--|--------------------------|
| e_ldmvgprw | Load multiple volatile general purpose registers (GPR) | r0, r3:r12 |
| e_stmvgprw | Store multiple volatile general purpose registers (GPR) | r0, r3:r12 |
| e_ldmvsprw | Load multiple volatile special purpose registers (SPR) | CR, LR, CTR, and XER |
| e_stmvsprw | Store multiple volatile special purpose registers (SPR) | CR, LR, CTR, and XER |
| e_ldmvsrrw | Load multiple volatile save and restore registers (SSR) | SRR0, SRR1 |
| e_stmvsrrw | Store multiple volatile save and restore registers (SSR) | SRR0, SRR1 |
| e_ldmvcsrww | Load multiple volatile critical save and restore registers (CSSR) | CSRR0, CSRR1 |
| e_stmvcsrww | Store multiple volatile critical save and restore registers (CSSR) | CSRR0, CSRR1 |
| e_ldmvsrrw | Load multiple volatile debug save and restore registers (DSRR) | DSRR0, DSRR1 |
| e_stmvsrrw | Store multiple volatile debug save and restore registers (DSRR) | DSRR0, DSRR1 |

[Figure 2](#) illustrates how these new instructions are implemented in an interrupt handler prolog.

```

e_stmvsrrw 0x04 (r1)      # Store SRRs (SRR0, SRR1) (must be done before
                          # enabling EE)
e_stmvsprw 0x38 (r1)     # Store SRRs (CR,LR,CTR,XER)

wrteei                  # Set MSR[EE]=1

e_stmvgprw 0x0C (r1)     # Store volatile GPRs (R0, R3-R12)

```

Figure 2. Interrupt Handler Prolog Using New Instructions

5 Instruction Listings

5.1 Load Multiple Volatile GPR Word

| | | | | |
|-------------|-----------------------|----|-----------------|----|
| e_lmvgprw | D8(RA)(D8-mode) | | | |
| 0 0 0 1 1 0 | 0 0 0 0 0 | RA | 0 0 0 1 0 0 0 0 | D8 |
| 0 | 6 | 11 | 16 | 24 |
| | | | | 31 |

```

if RA=0 then EA ← EXTS(D8)
else EA ← (GPR(RA)+EXTS(D8))

GPR(r0)32:63 ← MEM(EA, 4)
EA ← (EA+4)

r ← 3
do while r ≤ 12
    GPR(r)32:63 ← MEM(EA, 4)

EA ← (EA, 4)
r ← r + 1
    
```

Let the effective address (EA) be the sum of the contents of GPR(RA), or 0 if RA=0, and the sign-extended value of the D8 instruction field.

Bits 32:63 of registers GPR(R0), and GPR(R3) through GPR(12) are loaded from n consecutive words in storage starting at address EA.

EA must be a multiple of 4. If it is not, either an Alignment interrupt is invoked or the results are boundedly undefined.

Special registers altered: None

5.2 Store Multiple Volatile GPR Word

| | | | | |
|-------------|-----------------------|----|-----------------|----|
| e_stmvgprw | D8(RA)(D8-mode) | | | |
| 0 0 0 1 1 0 | 0 0 0 0 0 | RA | 0 0 0 1 0 0 0 1 | D8 |
| 0 | 6 | 11 | 16 | 24 |
| | | | | 31 |

```

if RA=0 then EA ← EXTS(D8)
else EA ← (GPR(RA)+EXTS(D8))

MEM(EA, 4) ← GPR(r0)32:63
EA ← (EA+4)

R ← 3
do while r ≤ 12
    MEM(EA, 4) ← GPR(r)32:63
    r ← r+1
    EA ← (EA+4)
    
```

Instruction Listings

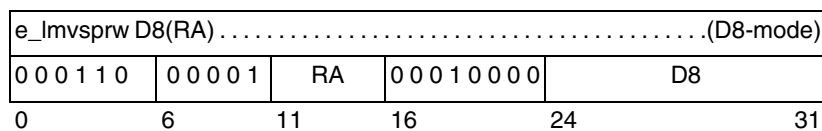
Let the effective address (EA) be the sum of the contents of GPR(RA), or 0 if RA=0, and the sign-extended value of the D8 instruction field.

Bits 32:63 of registers GPR(R0), and GPR(R3) through GPR(12) are stored in n consecutive words in storage starting at address EA.

EA must be a multiple of 4. If it is not, either an alignment interrupt is invoked or the results are boundedly undefined.

Special registers altered: None

5.3 Load Multiple Volatile SPR Word



```
if RA=0 then EA ← EXTS(D8)
else          EA ← (GPR(RA)+EXTS(D8))
```

```
CR32:63 ← MEM(EA, 4)
EA ← (EA+4)
```

```
LR32:63 ← MEM(EA, 4)
EA ← (EA+4)
```

```
CTR32:63 ← MEM(EA, 4)
EA ← (EA+4)
```

```
XER32:63 ← MEM(EA, 4)
```

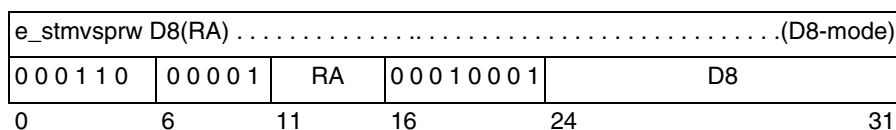
Let the effective address (EA) be the sum of the contents of GPR(RA), or 0 if RA=0, and the sign-extended value of the D8 instruction field.

Bits 32:63 of registers CR, LR, CTR, and XER are loaded from n consecutive words in storage starting at address EA.

EA must be a multiple of 4. If it is not, either an alignment interrupt is invoked or the results are boundedly undefined.

Special registers altered: CR, LR, CTR, XER

5.4 Store Multiple Volatile SPR Word



```
if RA=0 then EA ← EXTS(D8)
else          EA ← (GPR(RA)+EXTS(D8))
```

```
MEM(EA, 4) ← CR32:63
EA ← (EA+4)
```

```
MEM(EA, 4) ← LR32:63
EA ← (EA+4)
```

```
MEM(EA, 4) ← CTR32:63
EA ← (EA+4)
```

```
MEM(EA, 4) ← XER32:63
```

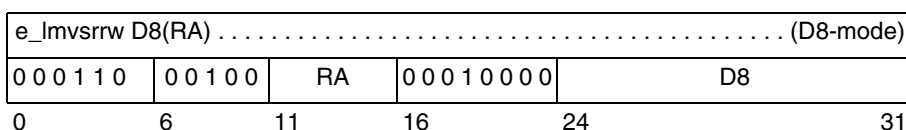
Let the effective address (EA) be the sum of the contents of GPR(RA), or 0 if RA=0, and the sign-extended value of the D8 instruction field.

Bits 32:63 of registers CR, LR, CTR, and XER are stored in n consecutive words in storage starting at address EA.

EA must be a multiple of 4. If it is not, either an alignment interrupt is invoked or the results are boundedly undefined.

Special registers altered: None

5.5 Load Multiple Volatile SRR Word



```
if RA=0 then EA ← EXTS(D8)
else          EA ← (GPR(RA)+EXTS(D8))
```

```
SRR032:63 ← MEM(EA, 4)
EA ← (EA+4)
```

```
SRR132:63 ← MEM(EA, 4)
```

Let the effective address (EA) be the sum of the contents of GPR(RA), or 0 if RA=0, and the sign-extended value of the D8 instruction field.

Bits 32:63 of registers SRR0 and SRR1 are loaded from consecutive words in storage starting at address EA.

EA must be a multiple of 4. If it is not, either an alignment interrupt is invoked or the results are boundedly undefined.

Special registers altered: SRR0, SRR1

5.6 Store Multiple Volatile SRR Word

| | | | | |
|-----------------------------------|-------|----|----------|----|
| e_stmvsrrw D8(RA) (D8-mode) | | | | |
| 000110 | 00100 | RA | 00010001 | D8 |
| 0 | 6 | 11 | 16 | 24 |
| | | | | 31 |

```
if RA=0 then EA ← EXTS(D8)
else      EA ← (GPR(RA)+EXTS(D8))
```

```
MEM(EA, 4) ← SRR032:63
EA ← (EA+4)
MEM(EA, 4) ← SRR132:63
```

Let the effective address (EA) be the sum of the contents of GPR(RA), or 0 if RA=0, and the sign-extended value of the D8 instruction field.

Bits 32:63 of registers SRR0 and SRR1 are stored in consecutive words in storage starting at address EA.

EA must be a multiple of 4. If it is not, either an alignment interrupt is invoked or the results are boundedly undefined.

Special registers altered: None

5.7 Load Multiple Volatile CSRR Word

| | | | | |
|----------------------------------|-------|----|----------|----|
| e_lmvsrrw D8(RA) (D8-mode) | | | | |
| 000110 | 00101 | RA | 00010000 | D8 |
| 0 | 6 | 11 | 16 | 24 |
| | | | | 31 |

```
if RA=0 then EA ← EXTS(D8)
else      EA ← (GPR(RA)+EXTS(D8))
```

```
CSRR032:63 ← MEM(EA, 4)
EA ← (EA+4)
CSRR132:63 ← MEM(EA, 4)
```

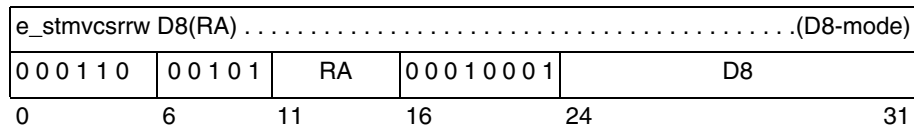
Let the effective address (EA) be the sum of the contents of GPR(RA), or 0 if RA=0, and the sign-extended value of the D8 instruction field.

Bits 32:63 of registers CSRR0 and CSRR1 are loaded from consecutive words in storage starting at address EA.

EA must be a multiple of 4. If it is not, either an alignment interrupt is invoked or the results are boundedly undefined.

Special registers altered: CSRR0, CSRR

5.8 Store Multiple Volatile CSRR Word



```

if RA=0 then EA ← EXTS(D8)
else          EA ← (GPR(RA)+EXTS(D8))
    
```

```

MEM(EA, 4) ← CSRR032:63
EA ← (EA+4)
MEM(EA, 4) ← CSRR132:63
    
```

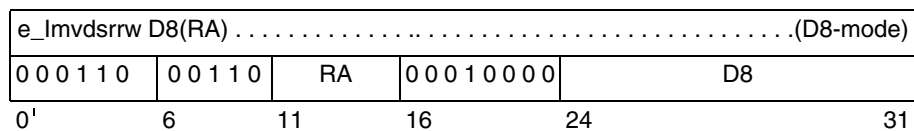
Let the effective address (EA) be the sum of the contents of GPR(RA), or 0 if RA=0, and the sign-extended value of the D8 instruction field.

Bits 32:63 of registers CSRR0 and CSRR1 are stored in consecutive words in storage starting at address EA.

EA must be a multiple of 4. If it is not, either an alignment interrupt is invoked or the results are boundedly undefined.

Special registers altered: None

5.9 Load Multiple Volatile DSRR Word



```

if RA=0 then EA ← EXTS(D8)
else          EA ← (GPR(RA)+EXTS(D8))
    
```

```

DSRR032:63 ← MEM(EA, 4)
EA ← (EA+4)
DSRR132:63 ← MEM(EA, 4)
    
```

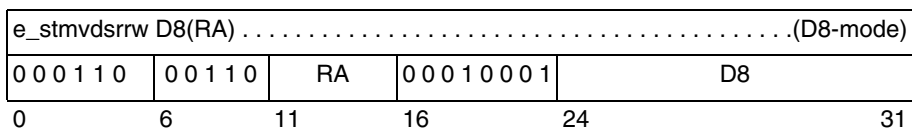
Let the effective address (EA) be the sum of the contents of GPR(RA), or 0 if RA=0, and the sign-extended value of the D8 instruction field.

Bits 32:63 of registers DSRR0 and DSRR1 are loaded from consecutive words in storage starting at address EA.

EA must be a multiple of 4. If it is not, either an alignment interrupt is invoked or the results are boundedly undefined.

Special registers altered: DSRR0, DSRR1

5.10 Store Multiple Volatile DSRR Word



```

if RA=0 then EA ← EXTS(D8)
else          EA ← (GPR(RA)+EXTS(D8))
    
```

```

MEM(EA, 4) ← DSRR032:63
EA ← (EA+4)
MEM(EA, 4) ← DSRR132:63
    
```

Let the effective address (EA) be the sum of the contents of GPR(RA), or 0 if RA=0, and the sign-extended value of the D8 instruction field.

Bits 32:63 of registers DSRR0 and DSRR1 are stored in consecutive words in storage starting at address EA.

EA must be a multiple of 4. If it is not, either an alignment interrupt is invoked or the results are boundedly undefined.

Special registers altered: None

6 Revision history

Table 5. Changes made April 2012¹

| Section | Description |
|------------|-----------------------------|
| Front page | Add SafeAssure branding. |
| 1 | Add Qorivva branding. |
| Back page | Apply new back page format. |

¹ No substantive changes were made to the content of this document; therefore the revision number was not incremented.

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