

Constants and literal pools

R. Ferrero, P. Bernardi

Politecnico di Torino

Dipartimento di Automatica e Informatica (DAUIN)

Torino - Italy



This work is licensed under the Creative Commons (CC BY-SA) License. To view a copy of this license, visit <http://creativecommons.org/licenses/by-sa/3.0/>



MOV

- It assigns a value to a register.
- The value can be:
 - the content of a register
 - a constant value.
- MOV cannot assign an instruction or data address

```
myCode    MOV r0, myData    ; error
```

```
          MOV r1, myCode    ; error
```

```
stopB stop
```

```
myData    DCD 0xC90147D2
```

MOV a register into another one

`MOV <Rd>, <Rm> {, shift}`

- **Example:** `MOV r0, r1`
- `shift` is an optional shift applied to `Rm`
 - `ASR #n`: arithmetic shift right
 - `LSL #n`: logical shift left
 - `LSR #n`: logical shift right
 - `ROR #n`: rotate right
 - `RRX`: rotate right 1 bit with sing extend

- The equivalent shift instruction is preferred:

`LSL r0, r1, #3` corresponds to `MOV r0, r1, LSL #3`

MOV a constant into a register

MOV <Rd>, #<constant>

- The constant can be:
 - a 16-bit value (0-65535)
 - a value obtained by shifting left an 8-bit value
 - of the form 0x00XY00XY
 - of the form 0xXY00XY00
 - of the form 0xXYXYXYXY.
- MOVW is like MOV, but it takes only a 16-bit value.

Shifted constant values

Left shift	Binary	Max decimal	Max hexadecimal
0	00000000000000000000000000000000xxxxxxx	255	0xFF
2	00000000000000000000000000000000xxxxxxx00	1020	0x3FC
4	00000000000000000000000000000000xxxxxxx0000	4080	0xFF0
6	00000000000000000000000000000000xxxxxxx000000	16320	0x3FC0
8	00000000000000000000000000000000xxxxxxx00000000	65280	0xFF00
...
20	0000xxxxxxx00000000000000000000000000000000	$0-255 \times 2^{20}$	0xFF00000
22	00xxxxxxx0000000000000000000000000000000000	$0-255 \times 2^{22}$	0x3FC00000
24	xxxxxxx000000000000000000000000000000000000	$0-255 \times 2^{24}$	0xFF000000

Which values are valid for MOV?

1. `MOV r0, #0x00004B4B`
2. `MOV r0, #0x004B4B00`
3. `MOV r0, #0x004B0000`
4. `MOV r0, #0x004B004B`
5. `MOV r0, #0x004B4B4B`
6. `MOV r0, #0x4B4B0000`
7. `MOV r0, #0x4B000000`
8. `MOV r0, #0x4B4B4B4B`

MVN (move negative)

- The `MVN` instruction moves a one's complement of the operand into a register.
- Same syntax as `MOV`, with one difference:
 - `MVN` does not accept a 16-bit value
- Example: `MVN r0, #0` -> `r0 = 0xFFFFFFFF`
- The assembler can change a `MOV` into a `MVN` if the value is valid for `MVN` and not for `MOV`.
- `MOV r0, #-2` becomes `MVN r0, #1` because `-2 = 0xFFFFFFFFE` is not in the range of `MOV`.

MOVT (move top)

- **MOVT** moves a 16-bit value in the high halfword of a register:

`MOVT <Rd>, #<constant>`

- A register can be set to any 32-bit constant by using **MOV** and **MOVT** together:

`MOV r0, #0x47D2`

`MOVT r0, #0xC901`

The new value of `r0` is `0xC90147D2`.

LDR for loading constants

- Besides loading values from memory, LDR can be used to load constants into registers:

LDR <Rd>, =<constant>

- If `constant` is among the valid values of MOV, then the instruction is replaced with:

MOV <Rd>, #<constant>

- Otherwise, a block of constant, called ***literal pool***, is created and the instruction becomes:

LDR <Rd>, [PC, #<offset>]

Computation of the offset

- The offset is the difference between the address of the literal pool and PC .
- The value of PC is computed as:
 1. the address of the current instruction
 2. plus 4
 3. clearing the second bit for word alignment.
- The offset is expressed with 12 bits.

Example of offset computation

LDR r0, =0xC90147D2	0x00000118
...	...
0x47D2	0x00000144
0xC901	0x00000146

1. $0x118 = 2_000100011000$
2. $0x118 + 4 = 0x11C = 2_000100011100$
3. $PC = 2_000100011100 = 0x11C$
4. $offset = 0x144 - 0x11C = 0x28 = 40$

LDR r0, [PC, #40]

Address of the literal pool

- By default, the literal pool is placed at the `END` directive, after the last instruction.
- As the offset is 12 bits, the distance between the current instruction and the last one should be lower than 4096.
- Otherwise, the `LTORG` directive must be used to put the literal pool somewhere else.

What is the error?

```
        AREA |.text|, CODE, READONLY
Reset_Handler PROC
        EXPORT Reset_Handler [WEAK]
        LDR r0, =0xC90147D2
stop B stop
myEmptySpace SPACE 4100
        ENDP
        END ;literal pool is saved here
```

Correct version

```
        AREA |.text|, CODE, READONLY

Reset_Handler    PROC

        EXPORT Reset_Handler [WEAK]

        LDR r0, =0xC90147D2

stop B stop

        LTORG ;literal pool is saved here

myEmptySpace    SPACE 4100

        ENDP

        END
```

Loading addresses into registers

- Two pseudo-instructions are available:

LDR <Rd>, =<label>

ADR <Rd>, <label>

- LDR creates a constant in a literal pool and uses a PC relative load to get the data.
- ADR adds or subtracts an offset to/from PC.
- ADR does not increase the code size, but it can not create all offsets
 - Addresses generated with ADR must be multiple of 4
 - ADR loads addresses in the same section.

LDR an address into a register

```
Stack_Size      EQU      0x00000200
                AREA STACK, NOINIT, READWRITE
Stack_Mem       SPACE    Stack_Size
```

```
                AREA |.text|, CODE, READONLY
```

...

```
LDR r12, =Stack_Mem
```

...

```
END ;literal pool is saved here
```


LDR an address into a register

- LDR can reference a label outside of the current section.
- In the previous example, `r12` is loaded with the address of the bottom of the stack

$$r12 = r13 - 0x00000200$$

ADR an address into a register

```
        AREA |.text|, CODE, READONLY
Reset_Handler PROC
    EXPORT Reset_Handler [WEAK]
    ADR r0, myData
stop B stop
myData DCD 0xC90147D2
myEmptySpace SPACE 4100
        ENDP
```

ADR and ADRL

- The ADR pseudo-instruction is replaced with

```
LDR <Rd>, [PC, #<offset>]
```
- The offset is expressed with 12 bits.
- If the offset is higher than 4095 bytes, ADRL must be used instead of ADR.
- ADRL generates two operations and its offset can be up to 1 MB.
- ADR and ADRL load addresses in the same section.

ADRL an address into a register

```
        AREA |.text|, CODE, READONLY
Reset_Handler PROC
        EXPORT Reset_Handler [WEAK]
        ADRL r0, myData
stop B stop
myEmptySpace SPACE 4100
myData DCD 0xC90147D2
        ENDP
```