

# Digital Functions

Nguyen Duc Hoang

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# Comparison Functions

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## Comparison Functions

|                          | Comparison according to data type |      |      |
|--------------------------|-----------------------------------|------|------|
| Comparison for           | INT                               | DINT | REAL |
| equal to                 | == I                              | == D | == R |
| not equal to             | <> I                              | <> D | <> R |
| greater than             | > I                               | > D  | > R  |
| greater than or equal to | >= I                              | >= D | >= R |
| less than                | < I                               | < D  | < R  |
| less than or equal to    | <= I                              | <= D | <= R |

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## Comparison Functions

| Syntax              |           |
|---------------------|-----------|
| Load                | Address 1 |
| Load                | Address 2 |
| Comparison function |           |
| Assign              | Result    |

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## Comparison Functions

### Notes:

- The result of the comparison is a binary digit, that is, either a 1 or a 0. A 1 indicates that the result of the comparison is true; a 0 indicates that the result of the comparison is false. This result is stored in RLO.
- When the CPU executes a Compare instruction, it also sets bits in the status word.

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## Comparison Functions

### Notes :

- A comparison function does not modify the contents of the accumulators. It is always executed without regard to any conditions.
- In the case of data type INT, the CPU compares only the low words of the accumulators; The contents of the high words are not taken into account.
- In comparisons involving data type REAL, a check is made to make sure that the accumulators contains valid REAL numbers. If they do not, the CPU sets the RLO to "0" and status bits CC0, CC1, OV and OS to "1".

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## Comparison Functions

| STL     | Explanation                                                                                                                 |
|---------|-----------------------------------------------------------------------------------------------------------------------------|
| L MW10  | Load the contents of memory word MW10 into accumulator 1.                                                                   |
| L IW0   | Load the contents of input word IW0 into accumulator 1. The old contents of accumulator 1 are shifted to accumulator 2.     |
| ==I     | Compare the value in the low word of accumulator 2 to the value in the low word of accumulator 1 to see if they are equal.  |
| = Q 4.0 | Output Q 4.0 will be energized if MW10 and IW0 are equal.                                                                   |
| >I      | Compare the value in the low word of accumulator 2 to see if it is greater than the value in the low word of accumulator 1. |
| = Q 4.1 | Output Q 4.1 will be energized if MW10 is greater than IW0.                                                                 |
| <I      | Compare the value in the low word of accumulator 2 to see if it is less than the value in the low word of accumulator 1.    |
| = Q 4.2 | Output Q 4.2 will be energized if MW10 is less than IW0.                                                                    |

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## Comparison Functions

| STL         | Explanation                                                                                                                            |
|-------------|----------------------------------------------------------------------------------------------------------------------------------------|
| L MD24      | Load the contents of memory double word MD24 into accumulator 1.                                                                       |
| L +1.00E+00 | Load the value 1 as a 32-bit floating-point number into accumulator 1. The old contents of accumulator 1 are shifted to accumulator 2. |
| >R          | Compare the value in accumulator 2 to see if it is greater than the value in accumulator 1.                                            |
| = Q 4.1     | Output Q 4.1 will be energized if MD24 is greater than 1.                                                                              |
| <R          | Compare the value in accumulator 2 to see if it is less than the value in accumulator 1.                                               |
| = Q 4.2     | Output Q 4.2 will be energized if MD24 is less than 1.                                                                                 |

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## Comparison Functions

```

L   MW120
L   512
>I
A   Input1
=   Output1

```

Output1 is set if the comparison condition is fulfilled and Input1 has signal state of "1".

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## Comparison Functions

```

O(   Input2
L   MW122
L   200
<=I
)
O(   Input3
=   Output2

```

Output2 is set if Input2 or Input3 has signal state of "1" or if the compare condition is fulfilled

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## Comparison Functions

```

L   MW124
L   1200
>I
JC  GREY
==I
JC  EQUA

```

```

L   MW124
L   1200
>I
JP  GREY
JZ  EQUA

```

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## Arithmetic Functions

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## Arithmetic Functions

| Arithmetic Functions              | With data type |      |      |
|-----------------------------------|----------------|------|------|
|                                   | INT            | DINT | REAL |
| Addition                          | + I            | + D  | + R  |
| Subtraction                       | - I            | - D  | - R  |
| Multiplication                    | * I            | * D  | * R  |
| Division with quotient as result  | / I            | / D  | / R  |
| Division with remainder as result | -              | MOD  | -    |

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## Arithmetic Functions

## Syntax

Load        Address 1  
Load        Address 2  
Arithmetic function  
Transfer    Result

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## Arithmetic Functions

| STL     | Explanation                                                                                                                                                     |
|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| L MW10  | Load the value of memory word MW10 into accumulator 1.                                                                                                          |
| L DBW12 | Load the value of data word DBW12 into accumulator 1. The old contents of accumulator 1 are shifted to accumulator 2.                                           |
| +I      | The CPU interprets the contents of the low words of accumulators 1 and 2 as 16-bit integers, adds them, and stores the result in the low word of accumulator 1. |
| T DBW14 | Transfer the contents of the low word of accumulator 1 (the result) to data word DBW14.                                                                         |

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## Arithmetic Functions

| STL     | Explanation                                                                                                                                                                                      |
|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| L MD100 | Load the value in memory double word MD100 into accumulator 1.                                                                                                                                   |
| L DBD4  | Load the value in data double word DBD4 into accumulator 1. The old contents of accumulator 1 are shifted to accumulator 2. (The values in these double words must be in floating-point format.) |
| +R      | The CPU interprets the contents of accumulators 1 and 2 as 32-bit IEEE floating-point numbers, adds them, and stores the result in accumulator 1.                                                |
| T DBD16 | Transfer the contents of accumulator 1 (the result) to data double word DBD16. (DBD16 = MD100 + DBD4)                                                                                            |

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## Arithmetic Functions

Result1: =Value1+ Value2-Value3

L Value1  
L Value2  
+I //Value1 + Value2  
L Value3  
-I //Sum - Value3  
T Result1

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## Arithmetic Functions

Result2: =Value5+ 2xValue6

L Value6  
L Value5  
+R //Value5 + Value6  
+R //Sum + Value6  
T Result2

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## Adding Constants to Accumulator 1

## Syntax

|                   |         |
|-------------------|---------|
| Load              | Address |
| Constant addition |         |
| Transfer          | Result  |



## Adding Constants to Accumulator 1

|   |            |
|---|------------|
| L | AddValue1  |
| + | B#16#21    |
| T | AddResult1 |

The value of variable AddValue1 is increased by 33 and transferred to variable AddResult1.



## Adding Constants to Accumulator 1

|   |            |
|---|------------|
| L | AddValue1  |
| + | L#-1       |
| T | AddResult1 |

The value of variable AddValue1 is decreased by -1 and transferred to variable AddResult1.



## Decrementing and Incrementing

|     |   |           |
|-----|---|-----------|
| DEC | n | Decrement |
| INC | n | Increment |

## Syntax

|           |           |
|-----------|-----------|
| Load      | Address   |
| Decrement | Decrement |
| Transfer  | Result    |

## Syntax

|           |           |
|-----------|-----------|
| Load      | Address   |
| Increment | Increment |
| Transfer  | Result    |



## Decrementing and Incrementing

|     |          |
|-----|----------|
| L   | IncValue |
| INC | 5        |
| T   | IncValue |

The value of variable IncValue is incremented by 5



## Decrementing and Incrementing

|     |          |
|-----|----------|
| L   | DecValue |
| DEC | 7        |
| T   | DecValue |

The value of variable DecValue is decremented by 7



# Math Functions

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## Math Functions

| Math Functions                                       | With data type   |
|------------------------------------------------------|------------------|
|                                                      | REAL             |
| Sine, cosine, tangent                                | SIN, COS, TAN    |
| Arc sine, arc cosine, arc tangent                    | ASIN, ACOS, ATAN |
| Squaring, square-root extraction                     | SQR, SQRT        |
| Exponential function to base e,<br>Natural logarithm | EXP, LN          |
| Absolute Value                                       | ABS              |

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## Math Functions

| STL    | Explanation                                            |
|--------|--------------------------------------------------------|
| L ID8  | //Load value into ACCU 1 (example: ID8 = -1.5E+02).    |
| ABS    | //Form the absolute value; store the result in ACCU 1. |
| T MD10 | //Transfer result to MD10 (example: result = 1.5E+02). |

| STL        | Explanation                                                                                                                   |
|------------|-------------------------------------------------------------------------------------------------------------------------------|
| OPW DB17   | Open data block DB17. (It is assumed that it contains the input value and will store the result).                             |
| L DBD0     | Load the value in data double word DBD0 into accumulator 1. (The value in this double word must be in floating-point format.) |
| SQR        | Calculate the square of the 32 bit IEEE floating-point number. Store the result in accumulator 1.                             |
| AN OV      | Check that the status bit OV is 0.                                                                                            |
| JC OK      | If operation SQR has no errors, jump to the label OK                                                                          |
| ...        | (In the event of an error an appropriate reaction takes place at this point.)                                                 |
| OK: T DBD4 | Transfer the result of accumulator 1 to data double word DBD4.                                                                |

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## Math Functions

Computing the idle power :  $P = U \times I \times \sin(\phi)$

|     |         |
|-----|---------|
| L   | PHI     |
| SIN |         |
| L   | Current |
| *R  |         |
| L   | Voltage |
| *R  |         |
| T   | I_Power |

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## Math Functions

Computing the volume of a cylinder :  $V=r^2 \times h$

|     |          |
|-----|----------|
| L   | Radius   |
| SQR |          |
| L   | Height   |
| *R  |          |
| L   | 3.141592 |
| *R  |          |
| T   | Volume   |

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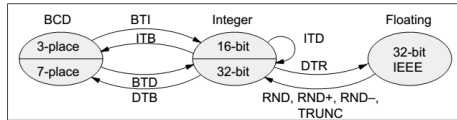
# Conversion Functions

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## Conversion Functions



## Conversion Functions

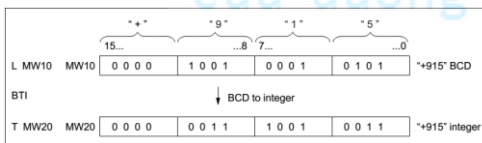
### Syntax

Load      Address  
Conversion function  
Transfer      Result



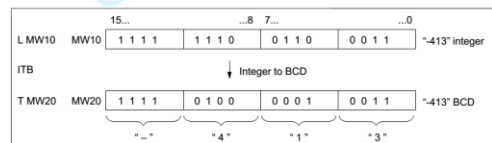
## Conversion Functions

| STL    | Explanation                                                                      |
|--------|----------------------------------------------------------------------------------|
| L MW10 | Load the BCD value in memory word MW10 into accumulator 1.                       |
| BTI    | Convert the BCD value to a 16-bit integer and store the result in accumulator 1. |
| T MW20 | Transfer the result to memory word MW20.                                         |



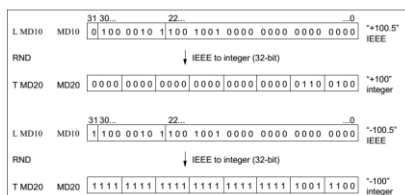
## Conversion Functions

| STL    | Explanation                                                                      |
|--------|----------------------------------------------------------------------------------|
| L MW10 | Load the 16-bit integer value in memory word MW10 into accumulator 1.            |
| ITB    | Convert the 16-bit integer to a BCD value and store the result in accumulator 1. |
| T MW20 | Transfer the result to memory word MW20.                                         |



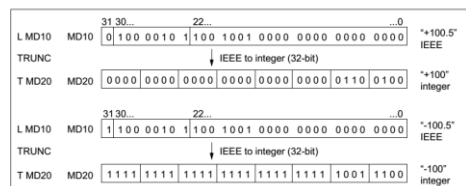
## Conversion Functions

| STL    | Explanation                                                                                                                             |
|--------|-----------------------------------------------------------------------------------------------------------------------------------------|
| L MD10 | Load the 32-bit IEEE floating-point value in memory double word MD10 into accumulator 1.                                                |
| RND    | Convert the 32-bit floating-point number to a 32-bit integer, round to the nearest whole number, and store the result in accumulator 1. |
| T MD20 | Transfer the result to memory double word MD20.                                                                                         |



## Conversion Functions

| STL    | Explanation                                                                                                                                                                                              |
|--------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| L MD10 | Load the 32-bit IEEE floating-point value in memory double word MD10 into accumulator 1.                                                                                                                 |
| TRUNC  | Convert the 32-bit floating-point number to a 32-bit integer. Round to the largest whole number less than or equal to the floating-point number that is converted and store the result in accumulator 1. |
| T MD20 | Transfer the result to memory double word MD20.                                                                                                                                                          |



# Shift and Rotate Functions

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## Shift and Rotate Functions

| Shift Functions          | Word  | Word | DW           | DW  |
|--------------------------|-------|------|--------------|-----|
| Shift left               | SLW n | SLW  | SLD n        | SLD |
| Shift right              | SRW n | SRW  | SRD n        | SRD |
| Shift with sign          | SSI n | SSI  | SSD n        | SSD |
| Rotate left              | -     | -    | RLD n        | RLD |
| Rotate right             | -     | -    | RRDn         | RRD |
| Rotate left through CC1  | -     | -    | RLDA (1 bit) | -   |
| Rotate right through CC1 | -     | -    | RRDA (1 bit) | -   |

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## Shift Functions

### Syntax

Load      Number\_of\_ positions  
Load      Address  
Shift function  
Transfer    Result

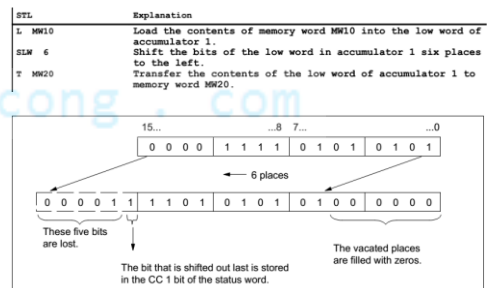
Load      Address  
Shift function    Number\_of\_ positions  
Transfer      Result

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## Shift Functions

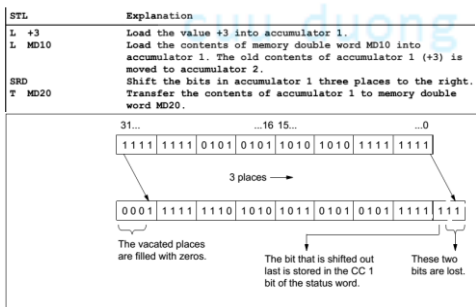


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## Shift Functions

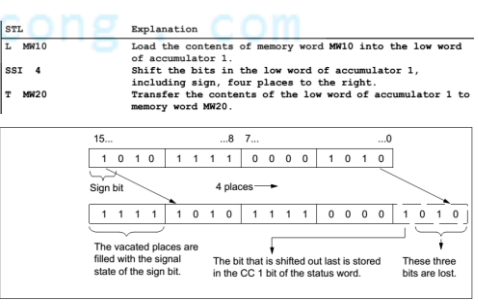


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## Shift Functions



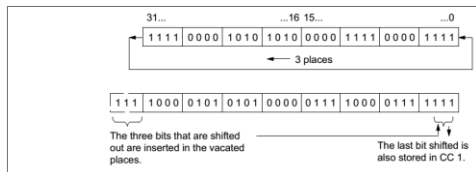
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## Rotate Functions

| STL    | Explanation                                                        |
|--------|--------------------------------------------------------------------|
| L MD10 | Load the contents of memory double word MD10 into accumulator 1.   |
| RLD 3  | Rotate the bits in accumulator 1 three places to the left.         |
| T MD20 | Transfer the contents of accumulator 1 to memory double word MD20. |



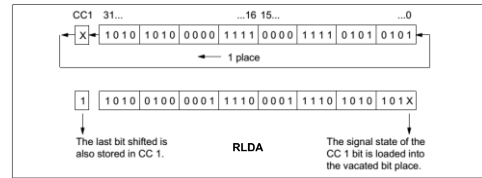
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## Rotate Functions

Rotating Accumulator 1 One Bit to the Left via the CC 1 Bit of the Status Word



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## Word Logic

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## Word Logic

| Word Logic   | Word | DW  |
|--------------|------|-----|
| And          | AW   | AD  |
| Or           | OW   | OD  |
| Exclusive Or | XOW  | XOD |

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## Word Logic

### Syntax

Load Address1  
Load Address2  
Word logic operation without constant  
Transfer Result

Load Address  
Word logic operation with constant  
Transfer Result

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## Word Logic

| STL    | Explanation                                                                                                                                                                                                       |
|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| L MW10 | Load the contents of memory word MW10 into accumulator 1.                                                                                                                                                         |
| L MW20 | Load the contents of memory word MW20 into accumulator 1. The old contents of accumulator 1 are shifted to accumulator 2.                                                                                         |
| AN     | The contents of the low word of accumulator 2 are combined bit by bit with the contents of the low word of accumulator 1 according to the AND truth table. The result is stored in the low word of accumulator 1. |
| T MW24 | Transfer the contents of accumulator 1 to memory word MW24.                                                                                                                                                       |



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## Word Logic

| STL                | Explanation                                                                                                                                         |
|--------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| L MD10             | Load the contents of memory double word MD10 into accumulator 1.                                                                                    |
| AD DW#16#AAAA_5555 | The contents of accumulator 1 are combined bit by bit with DW#16#AAAA_5555 according to the AND truth table. The result is stored in accumulator 1. |
| T MD24             | Transfer the contents of accumulator 1 to memory double word MD24.                                                                                  |

|                       |                                                               |
|-----------------------|---------------------------------------------------------------|
| MD10                  | 31... 16 15... 0                                              |
|                       | 0 1 1 0 1 0 0 1 1 0 0 0 0 0 0 1 1 0 0 0 0 0 0 0 1 0 1 0 1 1 1 |
| Value of AD statement | 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 |
|                       | AND bit by bit                                                |
| MD24                  | 0 0 1 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 1 |

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## Problems

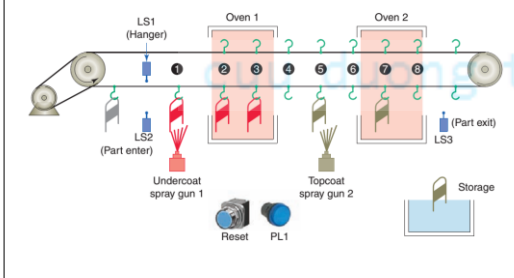
|    |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   |           |
|----|----|----|----|----|----|---|---|---|---|---|---|---|---|---|---|-----------|
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |           |
| 0  | 0  | 0  | 0  | 0  | 0  | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Positions |
| 0  | 0  | 0  | 0  | 0  | 0  | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Start     |
| 0  | 0  | 0  | 0  | 0  | 0  | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | Step 1    |
| 0  | 0  | 0  | 0  | 0  | 0  | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | Step 2    |
| 0  | 0  | 0  | 0  | 0  | 0  | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | Step 3    |
| 0  | 0  | 0  | 0  | 0  | 0  | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | Step 4    |

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## Problems



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