

# Altivar 12

Variable speed drives for asynchronous motors

## Modbus Communication Manual

04/2009





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# Important Information

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## NOTICE

Read these instructions carefully, and look at the equipment to become familiar with the device before trying to install, operate, or maintain it. The following special messages may appear throughout this documentation or on the equipment to warn of potential hazards or to call attention to information that clarifies or simplifies a procedure.



The addition of this symbol to a Danger or Warning safety label indicates that an electrical hazard exists, which will result in personal injury if the instructions are not followed.



This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

## **DANGER**

**DANGER** indicates an imminently hazardous situation, which, if not avoided, **will result** in death or serious injury.

## **WARNING**

**WARNING** indicates a potentially hazardous situation, which, if not avoided, **can result** in death or serious injury.

## **CAUTION**

**CAUTION** indicates a potentially hazardous situation, which, if not avoided, **can result** in minor or moderate injury.

## **CAUTION**

**CAUTION**, used without the safety alert symbol, indicates a potentially hazardous situation which, if not avoided, **can result** in property damage.

### PLEASE NOTE

The word "drive" as used in this manual refers to the controller portion of the adjustable speed drive as defined by NEC.

Electrical equipment should be installed, operated, serviced, and maintained only by qualified personnel. No responsibility is assumed by Schneider Electric for any consequences arising out of the use of this material.

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# Before you begin

Read and understand these instructions before performing any procedure with this drive.

## DANGER

### HAZARD OF ELECTRIC SHOCK, EXPLOSION, OR ARC FLASH

- Read and understand this manual before installing or operating the Altivar 12 drive. Installation, adjustment, repair, and maintenance must be performed by qualified personnel.
- The user is responsible for compliance with all international and national electrical code requirements with respect to grounding of all equipment.
- Many parts of this drive, including the printed circuit boards, operate at the line voltage. **DO NOT TOUCH.** Use only electrically insulated tools.
- **DO NOT** touch unshielded components or terminal strip screw connections with voltage present.
- **DO NOT** short across terminals PA/+ and PC/- or across the DC bus capacitors.
- Before servicing the drive:
  - Disconnect all power, including external control power that may be present.
  - Place a “DO NOT TURN ON” label on all power disconnects.
  - Lock all power disconnects in the open position.
  - **WAIT 15 MINUTES** to allow the DC bus capacitors to discharge. Then follow the “Bus Voltage Measurement Procedure” (see User manual) to verify that the DC voltage is less than 42 V. The drive LEDs are not indicators of the absence of DC bus voltage.
- Install and close all covers before applying power or starting and stopping the drive.

**Failure to follow these instructions will result in death or serious injury.**

## DANGER

### UNINTENDED EQUIPMENT OPERATION

- Read and understand this manual before installing or operating the Altivar 12 drive.
- Any changes made to the parameter settings must be performed by qualified personnel.

**Failure to follow these instructions will result in death or serious injury.**

## WARNING

### DAMAGED DRIVE EQUIPMENT

Do not operate or install any drive or drive accessory that appears damaged.

**Failure to follow these instructions can result in death, serious injury, or equipment damage.**

## WARNING

### LOSS OF CONTROL

- The designer of any control scheme must
  - consider the potential failure modes of control paths and, for certain critical control functions,
  - provide a means to achieve a safe state during and after a path failure.Examples of critical control functions are emergency stop and overtravel stop.
- Separate or redundant control paths must be provided for critical control functions.
- System control paths may include communication links. Consideration must be given to the implications of unanticipated transmission delays or failures of the link.<sup>a</sup>

**Failure to follow these instructions can result in death, serious injury, or equipment damage.**

a. For additional information, refer to NEMA ICS 1.1 (latest edition), “Safety Guidelines for the Application, Installation, and Maintenance of Solid State Control” and to NEMA ICS 7.1 (latest edition), “Safety Standards for Construction and Guide for Selection, Installation and Operation of Adjustable-Speed Drive Systems.”

# Documentation structure

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The following Altivar 312 technical documents are available on the Schneider Electric website ([www.schneider-electric.com](http://www.schneider-electric.com)) as well as on DVD-ROM (reference VW3A8200).

## User manual

This manual describes how to install, commission, operate and program the drive.

## Simplified manual

This manual is a simplified version of the User manual. This manual is delivered with the drive.

## Quick Start sheet

The Quick Start describes how to wire and configure the drive to start motor quickly and simply for simple applications. This document is delivered with the drive.

## Modbus Communication manual

This manual describes the assembly, connection to the bus or network, signaling, diagnostics, and configuration of the communication-specific parameters via the 7 segment LED display.

It also describes the communication services of the Modbus protocol.

This manual includes the main Modbus addresses.

It explains the operating mode specific to communication (state chart).

## ATV12P manual

This manual describes the features related to products mounted on baseplate.

## ATV12 Parameters description file

All the parameters are grouped together in an Excel file available on the Schneider Electric website ([www.schneider-electric.com](http://www.schneider-electric.com)), with the following data:

- Code
- Name
- Modbus Addresses
- Category
- Read/write access
- Type: signed numerical, unsigned numerical, etc.
- Unit
- Factory setting
- Minimum value
- Maximum value
- Display on the 7-segment integrated display terminal
- Relevant menu

This file offers the option of sorting and arranging the data according to any criterion chosen by the user.

## DANGER

### UNINTENDED EQUIPMENT OPERATION

- Read and understand this manual before installing or operating the Altivar 12 drive.
- Any changes made to the parameter settings must be performed by qualified personnel.
- The excel file does not describe the behaviour of the parameters. Before any modification, refer to the ATV12 User Manual.

**Failure to follow these instructions will result in death or serious injury.**

# Presentation

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The Modbus socket on the Altivar 12 can be used for the following functions:

- Configuration
- Settings
- Control
- Monitoring

The ATV12 drive supports:

- The 2-wire RS485 physical layer
- The RTU transmission mode

# Connection to RS485 bus

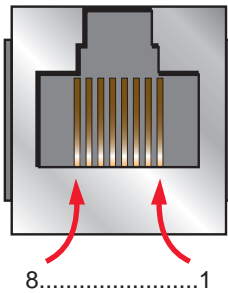
## Connection to ATV12

Connection accessories should be ordered separately (please consult our catalogues).

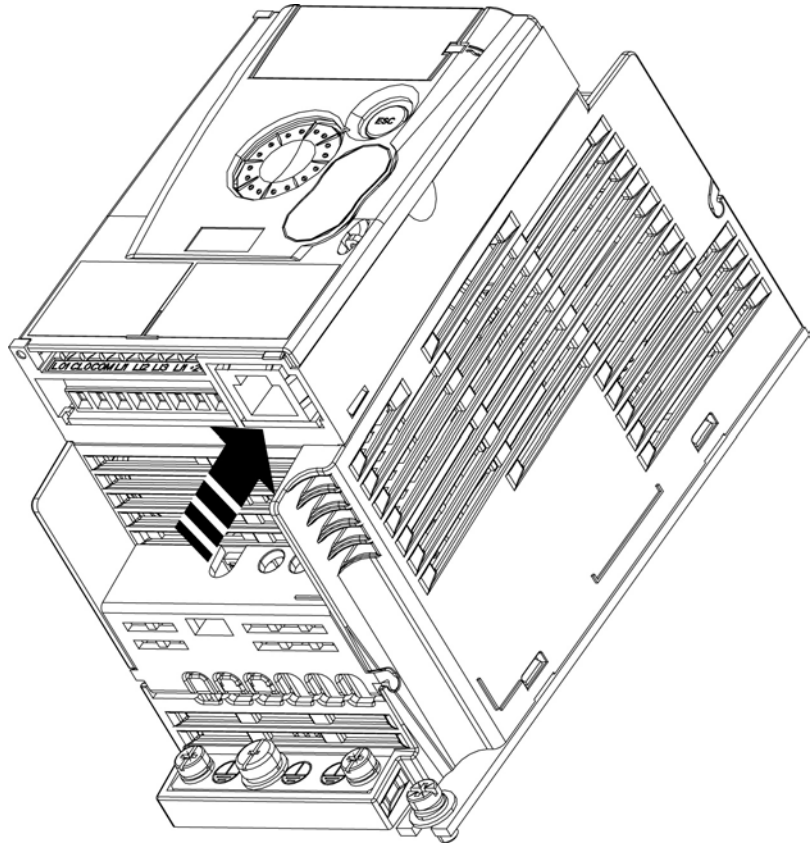
Connect the RJ45 cable connector to the ATV12 connector.

### Pin out of the ATV12 RJ45 Connector

View from underneath



| Pin | Signal     |
|-----|------------|
| 1   | -          |
| 2   | -          |
| 3   | -          |
| 4   | D1 (1)     |
| 5   | D0 (1)     |
| 6   | -          |
| 7   | VP (2)     |
| 8   | Common (1) |



(1) Modbus signals

(2) Supply for RS232 / RS485 converter or a remote terminal

## Protection against interference

- Use the Schneider Electric cable with 2 pairs of shielded twisted conductors (reference: TSXCSA100, TSXCSA200, TSXCSA500).
- Keep the Modbus cable separated from the power cables (30 cm (11.8 in.) minimum).
- Make any crossovers of the Modbus cable and the power cables at right-angles, if necessary.

For more information, please refer to the TSX DG KBL E manual: "Electromagnetic compatibility of industrial networks and fieldbuses".

## RS485 bus schematic

The RS485 standard allows variants of different characteristics:

- polarisation
- line terminator
- distribution of a reference potential
- number of slaves
- length of bus

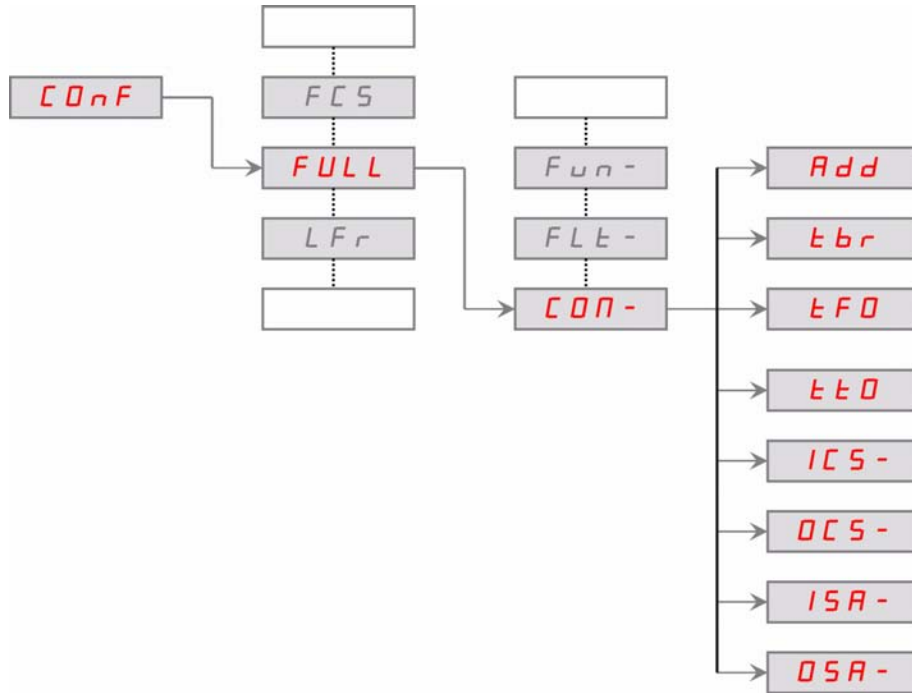
The new Modbus specification published on the Modbus.org site in 2002 contains precise details of all these characteristics. They are also summarised in Standard schematic section. The new Schneider Electric devices conform to this specification.



# Configuration of the Modbus serial port

## Communication Menu Structure

The communication parameters are part of the COM- submenu.  
This menu is accessible as follows:



## Communication configuration - Parameters description

| Parameter description                     | Range or listed values  | default   | Possible Value   | Modbus address  |
|---|---|-----------|--|-----------------|
| MODBUS address of the drive<br><i>Add</i> | 1 to 247<br>0 : OFF (broadcast only)  | OFF       | <i>OFF</i><br><i>1 . . . 247</i>                           | 16#1771 = 06001 |
| MODBUS baud rate<br><i>tbr</i>            | 4,8 kbps<br>9,6 kbps<br>19,2 kbps<br>38.4 kbps  | 19,2 kbps | <i>4. 8</i><br><i>9. 6</i><br><i>19. 2</i><br><i>38. 4</i> | 16#1773 = 06003 |
| MODBUS format<br><i>tFD</i>               | 8O1: 8 bits, odd parity, 1 stop bit.<br>8E1: 8 bits, even parity, 1 stop bit.<br>8N1: 8 bits, no parity, 1 stop bit<br>8N2: 8 bits, no parity, 2 stop bits. | 8E1       | <i>8o 1</i><br><i>8E 1</i><br><i>8n 1</i><br><i>8n 2</i>   | 16#1774 = 06004 |
| MODBUS Time out<br><i>tEO</i>             | Adjustable from 0.1 to 30s  | 10,0 s    | <i>tEO</i>   | 16#1775 = 06005 |
| <i>ICS-</i>                               | Communication scanner submenus :Detailed in the next chapter  |           |  |                 |
| <i>OCS-</i>                               |   |           |  |                 |
| <i>ISA-</i>                               |   |           |  |                 |
| <i>OSA-</i>                               |   |           |  |                 |

The behaviour of the ATV12 when a time-out occurs is defined by the *SLL* parameter, this parameter can be found in the menu *FLt-* (see User Manual).

### WARNING

#### LOSS OF CONTROL

If **Modbus fault management (SLL) = fault ignore (n0)**, communication control will be inhibited. For safety reasons, inhibition of communication fault should only be used for adjustment or special applications purpose.

**Failure to follow these instructions can result in death, serious injury, or equipment damage.**

# IO Scanner configuration parameters

## Integrated communication scanner

The communication scanner is useful when used in combination by the Modbus client device with the function "Read/Write Multiple registers" : 23 (0x17), which provides in a single telegram a read multiple registers and a write multiple registers. The detail of the function 23 is described in the supported Modbus functions

## Local configuration of the communication scanner

The communication scanner is accessible via the following menus : **CON -** and **ICS - OCS -** submenus.

The 4 output variables and the 4 input variables are assigned by means of parameters **nCA1** to **nCA4** and **nPA1** to **nPA4**. An **nCA** or **nPA** parameter with a value of zero indicates that the parameter is not active. These 8 parameters are described in the table.

NCA or NMA defines the addresses. All these parameters are Modbus eligible addresses.

| Submenu      | On the local HMI, it is parameter description                            | Factory setting parameter       | Modbus address                |
|--------------|--|---------------------------------|-------------------------------|
| <b>ICS -</b> | NMA1 ( <b>nPA1</b> )<br>Source drive address of the 1st input word       | Address of ETA=3201<br>16#0C81  | NMA1 address<br>12701 16#319D |
|              | NMA2 ( <b>nPA2</b> )<br>Source drive address of the 2nd input word       | Address of RFRD=8604<br>16#219C | NMA2 address<br>12702 16#319E |
|              | NMA3 ( <b>nPA3</b> )<br>Source drive address of the 3rd input word       | 0                               | NMA3 address<br>12703 16#319F |
|              | NMA4 ( <b>nPA4</b> )<br>Source drive address of the 4th input word       | 0                               | NMA4 address<br>12704 16#31A0 |
| <b>OCS -</b> | NCA1 ( <b>nCA1</b> )<br>Destination drive address of the 1st output word | Address of CMD=8501<br>16#2135  | NCA1 address<br>12721 16#31B1 |
|              | NCA2 ( <b>nCA2</b> )<br>Destination drive address of the 2nd output word | Address of LFRD=8602<br>16#219A | NCA2 address<br>12722 16#31B2 |
|              | NCA3 ( <b>nCA3</b> )<br>Destination drive address of the 3rd output word | 0                               | NCA3 address<br>12723 16#31B3 |
|              | NCA4 ( <b>nCA4</b> )<br>Destination drive address of the 4th output word | 0                               | NCA3 address<br>12724 16#31B4 |

## Monitoring the communication scanner

It is also possible to monitor the parameters value that have been configured in the communication scanner. This monitored values are accessible via the following menus : **CON -** and **ISA - OSA -** submenu.

The 4 output variable values and the 4 input variable values are located into parameters **nC1** to **nC4** and **nPI** to **nPI4**.

| Submenu      | On the local HMI, it is parameter description                       | Factory setting parameter | Modbus address               |
|--------------|---|---------------------------|------------------------------|
| <b>ISA -</b> | NM1 ( <b>nPI1</b> )<br>Source drive value of the 1st input word     | ETA value                 | NM1 address<br>12741 16#31C5 |
|              | NM2 ( <b>nPI2</b> )<br>Source drive value of the 2nd input word     | RFRD value                | NM2 address<br>12742 16#31C6 |
|              | NM3 ( <b>nPI3</b> )<br>Source drive value of the 3rd input word     | 0                         | NM3 address<br>12743 16#31C7 |
|              | NM4 ( <b>nPI4</b> )<br>Source drive value of the 4th input word     | 0                         | NM4 address<br>12744 16#31C8 |
| <b>OSA -</b> | NC1 ( <b>nC1</b> )<br>Destination drive value of the 1st input word | CMD value                 | NC1 address<br>12761 16#31D9 |
|              | NC2 ( <b>nC2</b> )<br>Destination drive value of the 2nd input word | LFRD value                | NC2 address<br>12762 16#31DA |
|              | NC3 ( <b>nC3</b> )<br>Destination drive value of the 3rd input word | 0                         | NC3 address<br>12763 16#31DB |
|              | NC4 ( <b>nC4</b> )<br>Destination drive value of the 4th input word | 0                         | NC4 address<br>12764 16#31DC |

# IO Scanner configuration parameters

## Configuration example

In this example the communication scanner is configured as follow, *nCA1*, *nCA2*, *nPA1*, *nPA2* are used with their default values. *nCA3* is configured with the address of *CP1* (Modbus 8504 16#2138). *nPA3* is configured with the address of *Et1* (Modbus 3206 16#0C86).

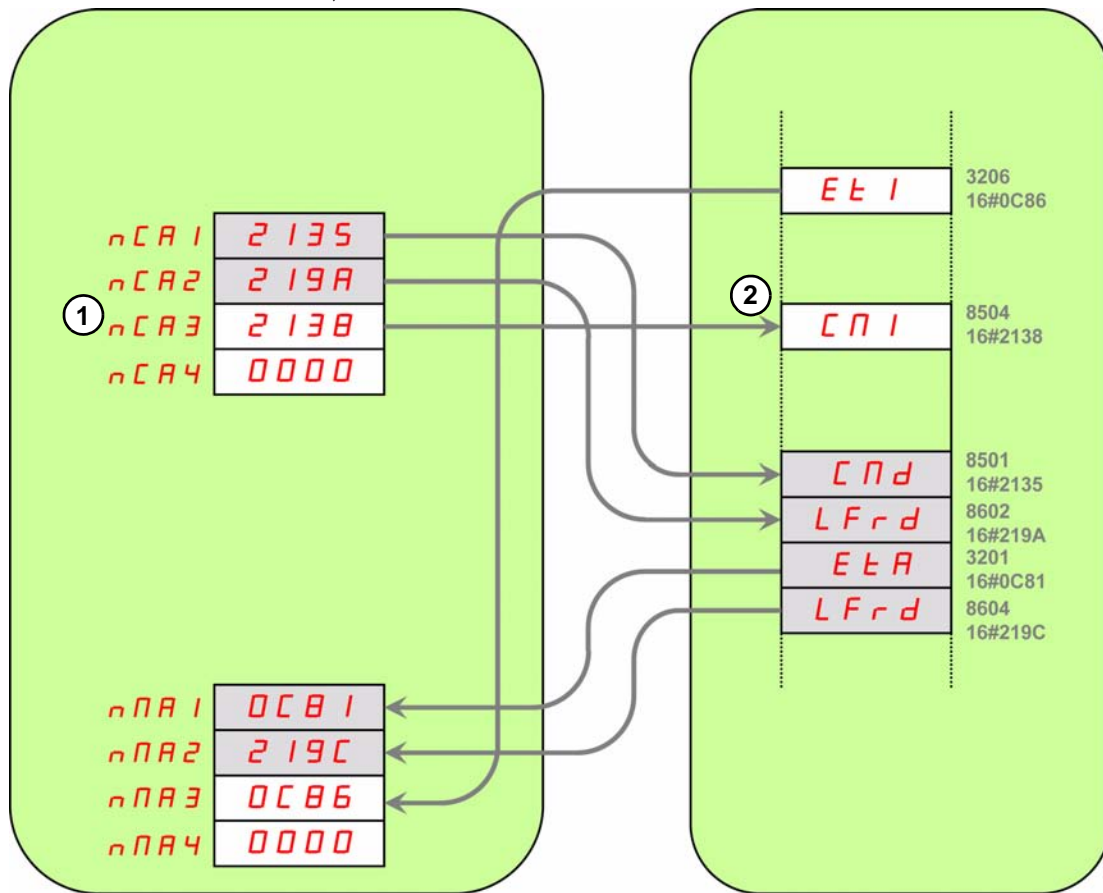
### How to read the diagram below

Example for *nCA3*:

*nCA3* (1) contain the logical address (2138) of *CP1* (2)

#### Communication scanner

- menu *CON-*
- submenu *CON-, OCS-*



The required telegram to perform the exchange is the Modbus function 23, Obviously a sequence of requests based on Modbus functions 03 and 16 is also possible.

(See also the chapters Modbus Functions and Altivar 12 and M340).

# Modbus Functions

## Modbus Protocol

The transmission mode used is RTU mode. The frame contains no message header byte, nor end of message bytes. It is defined as follows:



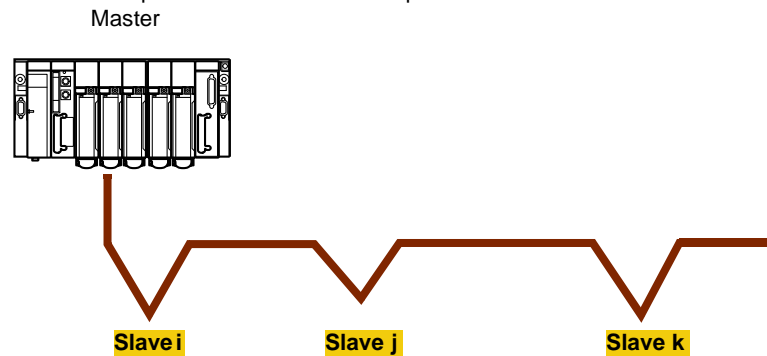
The data is transmitted in binary code.

CRC16: cyclical redundancy check.

The end of the frame is detected on a silence greater than or equal to 3 characters.

## Principle

The Modbus protocol is a master-slave protocol.



Only one device can transmit on the line at any time. The master manages the exchanges and only it can take the initiative. It interrogates each of the slaves in succession. No slave can send a message unless it is invited to do so. The master repeats the question when there is an incorrect exchange, and declares the interrogated slave absent if no response is received within a given time period. If a slave does not understand a message, it sends an exception response to the master. The master may or may not repeat the request.

Direct slave-to-slave communications are not possible.

For slave-to-slave communication, the application software must therefore be designed to interrogate a slave and send back data received to the other slave.

Two types of dialogue are possible between master and slaves:

- the master sends a request to a slave and waits for its response
- the master sends a request to all slaves without waiting for a response (broadcasting principle)

## Addresses

- The drive Modbus address can be configured from 1 to 247.
- Address 0 coded in a request sent by the master is reserved for broadcasting. ATV12 drives take account of the request, but do not respond to it.

## Supported Modbus functions

The Altivar 12 supports the following Modbus functions.

| Function name                                | Code                    | Description  | Remarks                                   |
|--|-------------------------|--|---|
| Read holding registers                       | 03<br>16#03             | Read N output words  | Max PDU length : 63 words                 |
| Write one output word                        | 06<br>16#06             | Write one output word  |   |
| Write multiple registers                     | 16<br>16#10             | Write N output word  | Max PDU length : 61 words                 |
| Read/write Multiple registers                | 23<br>16#17             | Read/write multiple registers                                    | Max PDU length : 4 words (W), 4 words (R) |
| (Sub-function)<br>Read device Identification | 43/14<br>16#2B<br>16#0E | Encapsulated interface transport<br>/ Read device identification |   |

# Modbus Functions

The following paragraphs describes each supported function.

## Read Holding registers

### Request

|                       |         |                  |
|-----------------------|---------|------------------|
| Function code         | 1 Byte  | <b>0x03</b>      |
| Starting Address      | 2 Bytes | 0x0000 to 0xFFFF |
| Quantity of Registers | 2 Bytes | 1 to 63 (0x 3F)  |

### Response

|                |              |             |
|----------------|--------------|-------------|
| Function code  | 1 Byte       | <b>0x03</b> |
| Byte count     | 1 Byte       | 2 x N*      |
| Register value | N* x 2 Bytes |             |

\*N: Quantity of Registers

### Error

|                |        |  |
|----------------|--------|--|
| Error code     | 1 Byte | <b>0x83</b>  |
| Exception code | 1 Byte | 01 or 02 or 03 or 04 (see details on page <a href="#">16</a> ) |

### Example

**Note:** Hi = high order byte, Lo = low order byte.

This function can be used to read all ATV12 words, both input words and output words.

#### Request

|           |        |                              |                            |                  |
|-----------|--------|------------------------------|----------------------------|------------------|
| Slave no. | 03     | No. of first word<br>Hi   Lo | Number of words<br>Hi   Lo | CRC16<br>Lo   Hi |
| 1 byte    | 1 byte | 2 bytes                      | 2 bytes                    | 2 bytes          |

#### Response

|           |        |                      |                             |       |                            |                  |
|-----------|--------|----------------------|-----------------------------|-------|----------------------------|------------------|
| Slave no. | 03     | Number of bytes read | First word value<br>Hi   Lo | ----- | Last word value<br>Hi   Lo | CRC16<br>Lo   Hi |
| 1 byte    | 1 byte | 1 byte               | 2 bytes                     |       | 2 bytes                    | 2 bytes          |

Example: read 4 words W3102 to W3105 (16#0C1E to 16#0C21) in slave 2, using function 3, where:

- SFr = Switching frequency = 4 kHz (W3102 = 16#0028)
- tFr = Maximum output frequency = 60 Hz (W3103 = 16#0258)
- HSP = High speed = 50 Hz (W3104 = 16#01F4)
- LSP = Low speed = 0 Hz (W3105 = 16#0000)

|         |    |    |      |      |      |
|---------|----|----|------|------|------|
| Request | 02 | 03 | 0C1E | 0004 | 276C |
|---------|----|----|------|------|------|

|          |    |    |             |       |       |       |       |      |
|----------|----|----|-------------|-------|-------|-------|-------|------|
| Response | 02 | 03 | 08          | 0028  | 0258  | 01F4  | 0000  | 52B0 |
|          |    |    | Value of:   | W3102 | W3103 | W3104 | W3105 |      |
|          |    |    | Parameters: | SFr   | tFr   | HSP   | LSP   |      |

# Modbus Functions

## Write one output word

### Request

|                  |         |                  |
|------------------|---------|------------------|
| Function code    | 1 Byte  | 0x06             |
| Register Address | 2 Bytes | 0x0000 to 0xFFFF |
| Register value   | 2 Bytes | 0x0000 to 0xFFFF |

### Response

|                  |         |                  |
|------------------|---------|------------------|
| Function code    | 1 Byte  | 0x06             |
| Register Address | 2 Bytes | 0x0000 to 0xFFFF |
| Register value   | 2 Bytes | 0x0000 to 0xFFFF |

### Error

|                |        |   |
|----------------|--------|---|
| Error code     | 1 Byte | 0x86  |
| Exception code | 1 Byte | 01 or 02 or 03 or 04 (see details on page 16) |

### Example

Request and response (the frame format is identical)

|           |        |             |               |         |
|-----------|--------|-------------|---------------|---------|
| Slave no. | 06     | Word number | Value of word | CRC16   |
|           |        | Hi   Lo     | Hi   Lo       | Lo   Hi |
| 1 byte    | 1 byte | 2 bytes     | 2 bytes       | 2 bytes |

Example: write value 16#000D in word W9001 (16#2329) in slave 2 (ACC = 13 s).

|                      |    |    |      |      |      |
|----------------------|----|----|------|------|------|
| Request and response | 02 | 06 | 2329 | 000D | 9270 |
|----------------------|----|----|------|------|------|

## Read/write Multiple registers

| Description            | Length in byte                      | Value                       | Comment  |
|------------------------|-------------------------------------|-----------------------------|--|
| Function code          | 1                                   | 16#17                       |  |
| Read starting address  | 2                                   | 16#XXXX                     | Always Modbus address  |
| Quantity to read       | 2                                   | 16#03                       | Contain number of holding registers to be read.  |
| Write starting address | 2                                   | 16#XXXX                     | Always Modbus address  |
| Quantity to write      | 2                                   | 16#03                       | Contain number of holding registers to be written.   |
| Write Byte count       | 1                                   | 16#06                       | The byte count specifies the number of bytes to follow in the field Write Register Value.    |
| Write Registers Value  | Nx2 Bytes<br>(N: quantity to write) | 16#XX<br>XXXX<br>XXXX<br>XX | Value to be written respectively in NCA1 to NCA3, so the configured example: CMD, LFRD, CMI. |

### Example

|          |               |                          |                           |        |                           |                            |        |  |
|----------|---------------|--------------------------|---------------------------|--------|---------------------------|----------------------------|--------|--|
| Slave n° | Function Code | Read starting Address HI | Read starting Address LOW | Qty    | Write starting Address HI | Write starting Address LOW | Qty    |  |
| 1 byte   | 1 byte        | 1 byte                   | 1 byte                    | 2 byte | 1 byte                    | 1 byte                     | 2 byte |  |

|                  |                    |            |  |            |                                  |        |
|------------------|--------------------|------------|--|------------|----------------------------------|--------|
| Write byte count | Writing Value 1 HI | Value 1 Lo |  | Value 1 HI | Writing Value 1.. 2... 3...n ... | CRC16  |
| 1 byte           | 1 byte             | 1 byte     |  | 1 byte     | 1 byte                           | 2 byte |

# Modbus Functions

## Read Device Identification

| ID   | Name / Description | Type         |
|------|--------------------|--------------|
| 0x00 | VendorName         | ASCII String |
| 0x01 | ProductCode        | ASCII String |
| 0x02 | MajorMinorRevision | ASCII String |

### Example

#### Default values to be detailed

Request

|           |        |                   |                    |                 |                  |  |
|-----------|--------|-------------------|--------------------|-----------------|------------------|--|
| Slave no. | 2B     | Type of MEI<br>0E | ReadDeviceld<br>01 | Object Id<br>00 | CRC16<br>Lo   Hi |  |
| 1 byte    | 1 byte | 1 byte            | 1 byte             | 1 byte          | 2 bytes          |  |

Response

|           |                                   |                              |   |                            |       |
|-----------|-----------------------------------|------------------------------|---|----------------------------|-------|
| Slave no. | 2B                                | Type of MEI<br>0E            | ReadDeviceld<br>01                            | Degree of conformity<br>02 | ----- |
| 1 byte    | 1 byte                            | 1 byte                       | 1 byte  | 1 byte                     |       |
| -----     | Number of additional frames<br>00 |                              | Next object Id<br>00                          | Number of objects<br>03    | ----- |
|           | 1 byte                            |                              | 1 byte  | 1 byte                     |       |
| -----     | Id of object no. 1<br>00          | Length of object no. 1<br>12 | Value of object no. 1<br>"Schneider Electric" |                            | ----- |
|           | 1 byte                            | 1 byte                       | 18 bytes                                      |                            |       |
| -----     | Id of object no. 2<br>01          | Length of object no. 2<br>0B | Value of object no. 2<br>"ATV12HU75M3"        |                            | ----- |
|           | 1 byte                            | 1 byte                       | 11 bytes                                      |                            |       |
| -----     | Id of object no. 3<br>02          | Length of object no. 3<br>04 | Value of object no. 3<br>"0201"               |                            | ----- |
|           | 1 byte                            | 1 byte                       | 4 bytes                                       |                            |       |
| -----     | CRC16<br>Lo   Hi                  |                              |   |                            |       |
|           | 1 byte                            | 1 byte                       |   |                            |       |

The total response size equals 49 bytes

The three objects contained in the response correspond to the following objects:

- Object no. 1: Manufacturer name (always "Schneider Electric", ie. 18 bytes).
- Object no. 2: Device reference (ASCII string; *for example*: "ATV12HU75M3", ie. 11 bytes).
- Object no. 3: Device version, in "MMmm" format where "MM" represents the determinant and "mm" the subdeterminant (4-bytes ASCII string; *for example*: "0201" for version 2.1).

**Note:** The response to function 43 may be negative; in this case, the response located at the top of the next page is sent by the Altivar 12 rather than the response described above.

# Modbus Functions

---

## Error management

### Exception responses

An exception response is returned by a slave when it is unable to perform the request which is addressed to it.

Format of an exception response:

|           |               |            |         |    |
|-----------|---------------|------------|---------|----|
| Slave no. | Response code | Error code | CRC16   |    |
|           |               |            | Lo      | Hi |
| 1 byte    | 1 byte        | 1 byte     | 2 bytes |    |

**Response code:** request function code + 16#80.

#### Error code:

- 1 = The function requested is not recognized by the slave
- 2 = The bit or word addresses indicated in the request do not exist in the slave
- 3 = The bit or word values indicated in the request are not permissible in the slave
- 4 = The slave has started to execute the request but cannot continue to process it completely

### CRC16 calculation

The CRC16 is calculated on all the message bytes by applying the following method:

Initialize the CRC (16-bit register) to 16#FFFF.

Enter the first to the last byte of the message:

```
CRC      XOR      <byte> —> CRC
Enter    8 times
         Move the CRC one bit to the right
         If the output bit = 1, enter CRC XOR 16#A001—> CRC
End enter
End enter
```

The CRC obtained will be transmitted with the low order bytes sent first, followed by the high order ones (unlike the other data contained in Modbus frames).

XOR = exclusive OR.

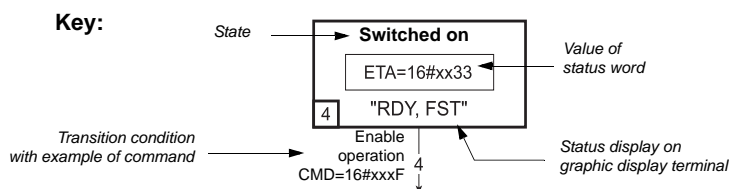
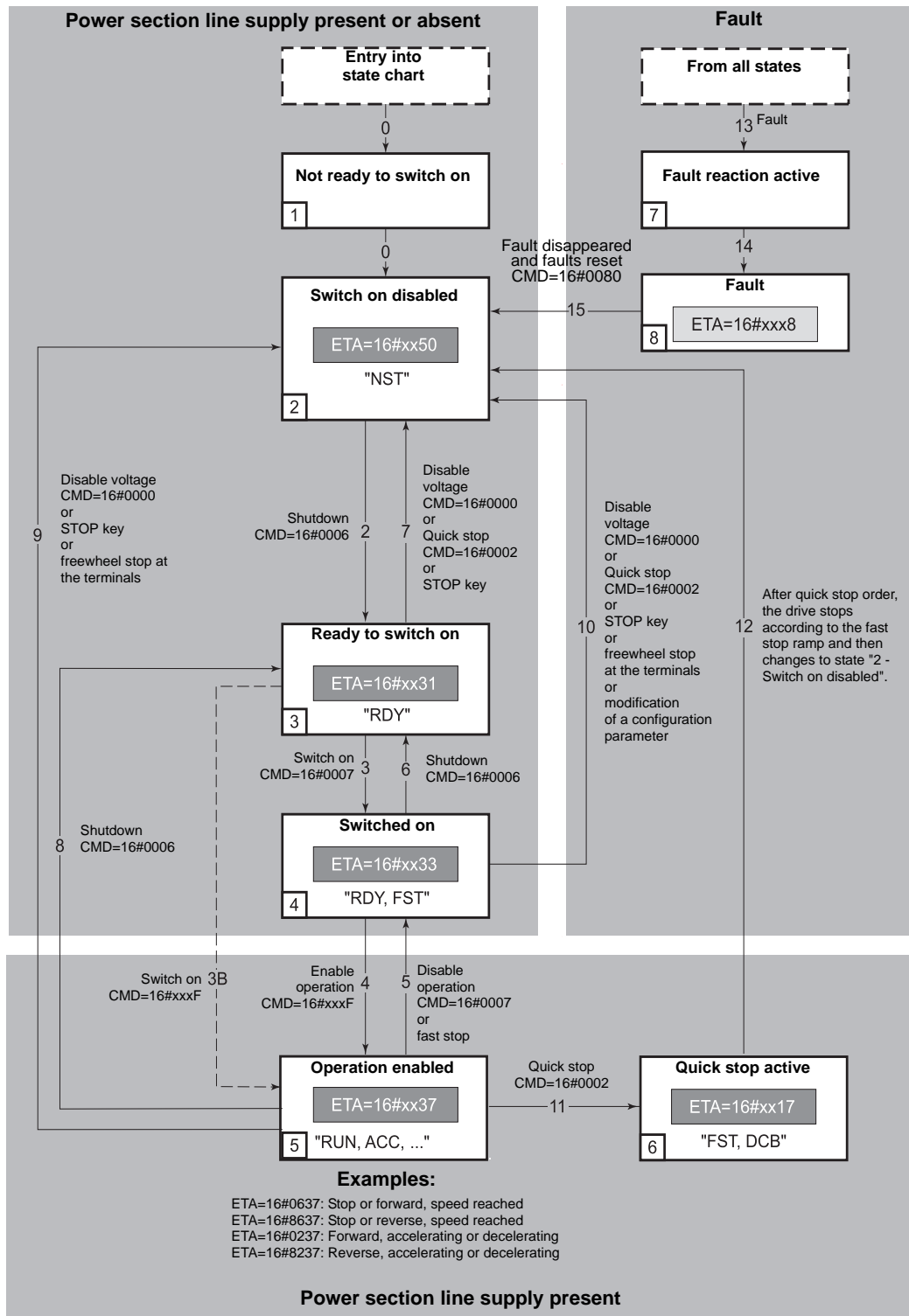


# ATV12 state machine

## Status chart based on IEC 61800-7\*

The state machine below describes the interaction between the drive's state machine, monitored by the status word (ETA) parameter, and the Command Word (CMD).

\*:Since 2007, CiA402 profile is part of the IEC standard 61800-7. Therefore DriveCom or CiA402 terminology is no more used.



# ATV12 state machine

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## State machine description

The Altivar control process using the communication bus follows IEC 61800-7 profile status chart compatible with the DRIVECOM standard. Each state represents an aspect of the internal behaviour of the drive.

This chart evolves according to whether the control word is sent (CMD W8501) or an event occurs (example: lock following malfunction). The drive status can be identified by the value of the status word (ETA W3201).

### Not ready to switch on (Initialization):

Communication is being initialized.  
Transient state invisible to the communication bus.

### Switch on disabled (Configuration):

Initialization of the drive is complete.  
The configuration and adjustment parameters can be modified. The drive is locked.

### Ready to switch on and Switched on (Drive initialized):

The drive is locked.  
The power stage of the drive is ready to operate, but voltage has not yet been applied to the output.  
The configuration and adjustment parameters can be modified, but modifying a configuration parameter returns the drive to the "Switch on disabled" state.

### Operation enabled (Operational):

The drive is unlocked and voltage can be applied to the motor terminals.  
Auto-tuning (tUn) requires an injection of current. The drive must therefore be in this state to perform this command.  
The adjustment parameters can be modified even if a run command or a DC injection current is present. However, a configuration parameter can only be modified if the motor is stopped, and this returns the drive to the "Switch on disabled" state.

### Quick stop active (Emergency stop active):

Fast stop  
Restarting is only possible after the drive has changed to the "Switch on disabled" state.

### Malfunction reaction active (Reaction on fault):

Transient state during which the drive performs an action appropriate to the type of fault detection.

### Malfunction (Fault):

The drive is locked.

## Summary

| State                      | Power supplied to motor                   | Modification of configuration parameters      |
|----------------------------|---|---|
| 1 - Not ready to switch on | No  | Yes   |
| 2 - Switch on disabled     | No  | Yes   |
| 3 - Ready to switch on     | No  | Yes   |
| 4 - Switched on            | No  | Yes, return to "2 - Switch on disabled" state |
| 5 - Operation enabled      | Yes, except at zero reference or "halt"   | No  |
| 6 - Quick stop active      | Yes, during fast stop                     | No  |
| 7 - Fault reaction active  | Depends on fault management configuration | -   |
| 8 - Fault                  | No  | Yes   |

# ATV12 state machine

## Command word description CMD - 8501

| bit 7                              | bit 6         | bit 5         | bit 4                                       | bit 3                                      | bit 2  | bit 1   | bit 0     |
|------------------------------------|---------------|---------------|---|--|--|---|-----------|
| 0 to 1 transition :<br>Fault reset | Reserved (=0) | Reserved (=0) | 0:Free wheel staying in "Operation Enabled" | Enable operation Drivecom state activation | Quick stop Drivecom state activation (bit active at 0) | Switch on disabled. Drivecom state activation (bit active at 0) | Switch on |

| bit 15   | bit 14         | bit 13   | bit 12   | bit 11  | bit 10        | bit 9         | bit 8         |
|----------|----------------|----------|----------|---|---------------|---------------|---------------|
| Reserved | Not assignable | Reserved | Reserved | Direction of rotation asked<br>0: Forward<br>1: Reverse | Reserved (=0) | Reserved (=0) | 0: RUN asked  |
|          |                |          |          |   |               |               | 1: STOP asked |

| Command           | Transition address | Final state            | bit 7       | bit 3            | bit 2      | bit 1              | bit 0     | Example value |
|-------------------|--------------------|------------------------|-------------|------------------|------------|--------------------|-----------|---------------|
|                   |                    |                        | Fault reset | Enable operation | Quick stop | Switch on disabled | Switch on |               |
| Shutdown          | 2, 6, 8            | 3 - Ready to switch on | x           | x                | 1          | 1                  | 0         | 16#0006       |
| Switch on         | 3                  | 4 - Switched on        | x           | x                | 1          | 1                  | 1         | 16#0007       |
| Enable operation  | 4                  | 5 - Operation enabled  | x           | 1                | 1          | 1                  | 1         | 16#000F       |
| Disable operation | 5                  | 4 - Switched on        | x           | 0                | 1          | 1                  | 1         | 16#0007       |
| Disable voltage   | 7, 9, 10, 12       | 2 - Switch on disabled | x           | x                | x          | 0                  | x         | 16#0000       |
| Quick stop        | 11                 | 6 - Quick stop active  | x           | x                | 0          | 1                  | x         | 16#0002       |
|                   | 7, 10              | 2 - Switch on disabled |             |                  |            |                    |           |               |
| Fault reset       | 15                 | 2 - Switch on disabled | 0 ◦ 1       | x                | x          | x                  | x         | 16#0080       |

x: Value is of no significance for this command.

0 ◦ 1: Command on rising edge.

# ATV12 state machine

## Status word description ETA - 3201

| bit 7               | bit 6              | bit 5                        | bit 4                                  | bit 3                      | bit 2             | bit 1       | bit 0              |
|---------------------|--------------------|------------------------------|--|----------------------------|-------------------|-------------|--------------------|
| Reserved (always 0) | Switch on disabled | Quick stop (bit active at 0) | Powerstage is supplied (bit always on) | Malfunction, fault present | Operation enabled | Switched on | Ready to switch on |

| bit 15  | bit 14            | bit 13        | bit 12        | bit 11                              | bit 10                           | bit 9                        | bit 8         |
|---|-------------------|---------------|---------------|-------------------------------------|----------------------------------|------------------------------|---------------|
| 0: Motor rotation in forward direction (or stopped) | Stop via STOP key | Reserved (=0) | Reserved (=0) | Reference exceeded (< LSP or > HSP) | Reference reached (steady state) | Local mode (bit active at 0) | Reserved (=0) |

| Status                     | bit 6                | bit 5      | bit 4           | bit 3 | bit 2             | bit 1       | bit 0              | ETA<br>masked by<br>16#006F (1) |
|----------------------------|----------------------|------------|-----------------|-------|-------------------|-------------|--------------------|---------------------------------|
|                            | Switched on disabled | Quick stop | Voltage enabled | Fault | Operation enabled | Switched on | Ready to switch on |                                 |
| 1 - Not ready to switch on | 0                    | x          | x               | 0     | 0                 | 0           | 0                  | -                               |
| 2 - Switch on disabled     | 1                    | x          | x               | 0     | 0                 | 0           | 0                  | 16#0040                         |
| 3 - Ready to switch on     | 0                    | 1          | x               | 0     | 0                 | 0           | 1                  | 16#0021                         |
| 4 - Switched on            | 0                    | 1          | 1               | 0     | 0                 | 1           | 1                  | 16#0023                         |
| 5 - Operation enabled      | 0                    | 1          | 1               | 0     | 1                 | 1           | 1                  | 16#0027                         |
| 6 - Quick stop active      | 0                    | 0          | 1               | 0     | 1                 | 1           | 1                  | 16#0007                         |
| 7 - Fault reaction active  | 0                    | x          | x               | 1     | 1                 | 1           | 1                  | -                               |
| 8 - Fault                  | 0                    | x          | x               | 1     | 0                 | 0           | 0                  | 16#0008 (2)<br>or 16#0028       |

x: In this state, the value of the bit can be 0 or 1.

(1) This mask can be used by the PLC program to test the chart state.

(2) Fault following state "6 - Quick stop active".

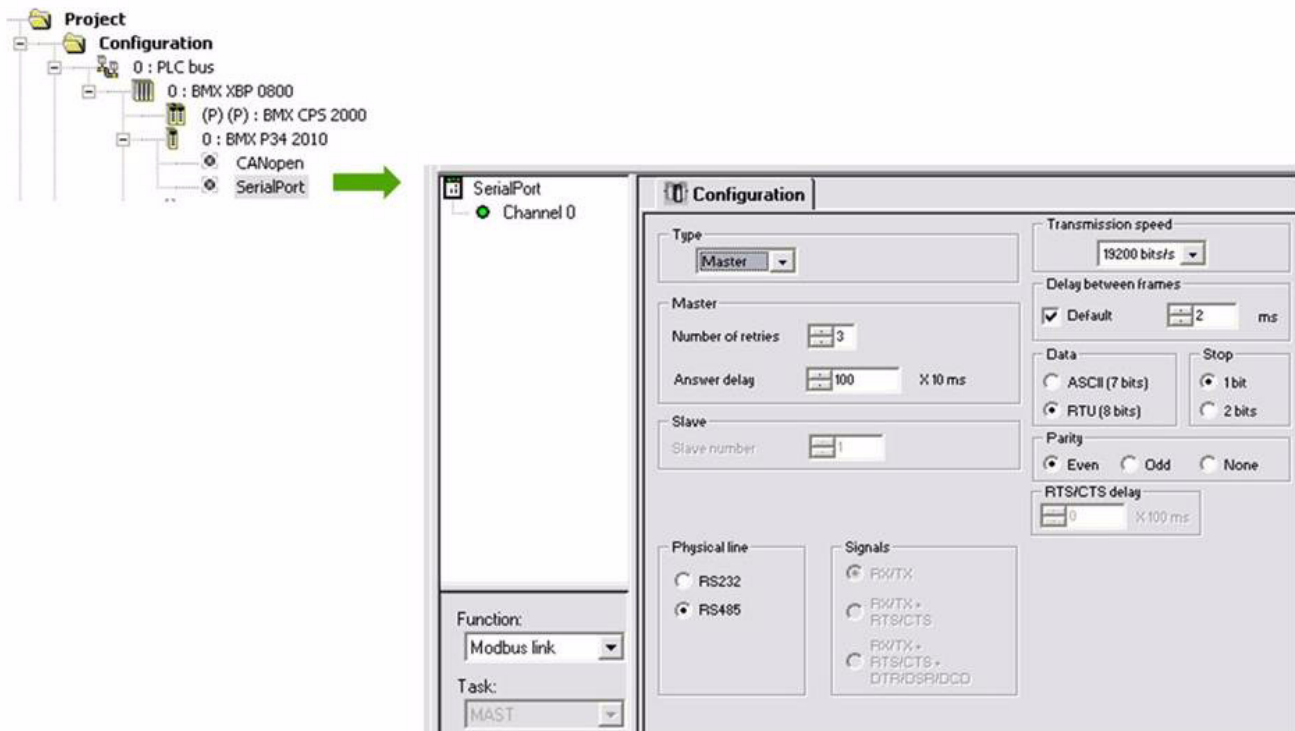
# Application example

## Connecting an ATV12 to a M340 PLC

Here is an example of an application that shows how to control an ATV12 from a M340 PLC equipped with a Modbus master serial port. The program provides a control of the drive from an operator screen designed under Unity. The example illustrates also the previous chapter

## Configuration of the Modbus Master

The default settings of the serial port used as a Modbus master are compliant with the default settings of the ATV12.



# Application example

## Initialization

The communication is based on the READ\_VAR , WRITE\_VAR functions. During the first execution of the MAST task you can initialize the data structures used by these two functions. Devicepath describes the path to the device including its slave address. ReadVarMgt and WriteVarMgt are arrays used respectively by READ\_VAR and WRITE\_VAR. Only the 3rd element of these arrays is modifiable by the user: To define the time out duration of the requests

```
(* data initialization *)  
  
(* Communication path to Modbus slave device at @ 3 *)  
(* The device path can be modified later by the app. *)  
(* MSB of DevicePath[3] contains the device address *)  
DevicePath := ADDM ('0.0.0.3');  
(* Time out duration *)  
ReadVarMGT[2] :=50;  
WriteVarMGT[2] :=50;
```

### Data structure declaration :

| DevicePath    | ADDM_TYPE | %Mw50 |
|---------------|-----------|-------|
| DevicePath[0] | INT       | %Mw50 |
| DevicePath[1] | INT       | %Mw51 |
| DevicePath[2] | INT       | %Mw52 |
| DevicePath[3] | INT       | %Mw53 |
| DevicePath[4] | INT       | %Mw54 |
| DevicePath[5] | INT       | %Mw55 |
| DevicePath[6] | INT       | %Mw56 |
| DevicePath[7] | INT       | %Mw57 |

| ReadVarMGT    | MBMgtTable | %Mw40 |
|---------------|------------|-------|
| ReadVarMGT[0] | INT        | %Mw40 |
| ReadVarMGT[1] | INT        | %Mw41 |
| ReadVarMGT[2] | INT        | %Mw42 |
| ReadVarMGT[3] | INT        | %Mw43 |

# Application example

## Cyclical exchanges

In the example below the application manages 2 requests:

- "A read request of 4 words starting at Modbus address 12741 (NMA1) - Modbus function #3
- "A write request of 4 words starting at Modbus address 12761 (NCA1) - Modbus function #16

Requests are executed only each N x FAST task to avoid too much activity on the serial line.

The device can be modified (polling several devices) by writing in DevicePath[3].

## Cyclical communication

```
(* Modbus Requests are sent only each:  
( ModbusRequestPeriod X FAST period X n) *)  
if ModbusRequestPeriod >25 then  
(* Read request to ATV12 : Modbus function 3 *)  
IF not ReadVarBusy then  
READ_VAR(DevicePath, '%MW' , 12741, 4, ReadVarMGT, %MW124:4);  
(*Devicepath is initialized during Init_Sequence *)  
END_IF;  
  
(* Write request to ATV12 : Modbus function 16 *)  
IF not WriteVarBusy then  
WRITE_VAR(DevicePath, '%MW' , 12761, 4, %MW120:4, WriteVarMGT);  
  
END_IF;  
ModbusRequestPeriod:=0;  
END_IF;
```

The key data are highlighted: address and length in the device source and destination of the data in the PLC.

The time out can be managed by the application in a separate way by testing the activity of the 2 bits: ReadVarBusy and WriteVarBusy

### Overview of the communication tables:

| Name        | Type        | Address | Value | Comment                                  |
|-------------|-------------|---------|-------|--|
| ATV12_NC    | ATV12IOSCAN | %MW120  |       | ATV12 com scanner IN (PLC > ATV)         |
| ATV12_NC[0] | INT         | %MW120  |       | default : ATV 12 CMD Control Word        |
| ATV12_NC[1] | INT         | %MW121  |       | default : ATV12 LFRD Frequency reference |
| ATV12_NC[2] | INT         | %MW122  |       |  |
| ATV12_NC[3] | INT         | %MW123  |       |  |
| ATV12_NM    | ATV12IOSCAN | %MW124  |       | ATV12 COM scanner OUT (ATV > PLC )       |
| ATV12_NM[0] | INT         | %MW124  |       | default : ATV 12 ETA (status word )      |
| ATV12_NM[1] | INT         | %MW125  |       | default : ATV 12 RFRD Output speed       |
| ATV12_NM[2] | INT         | %MW126  |       |  |
| ATV12_NM[3] | INT         | %MW127  |       |  |

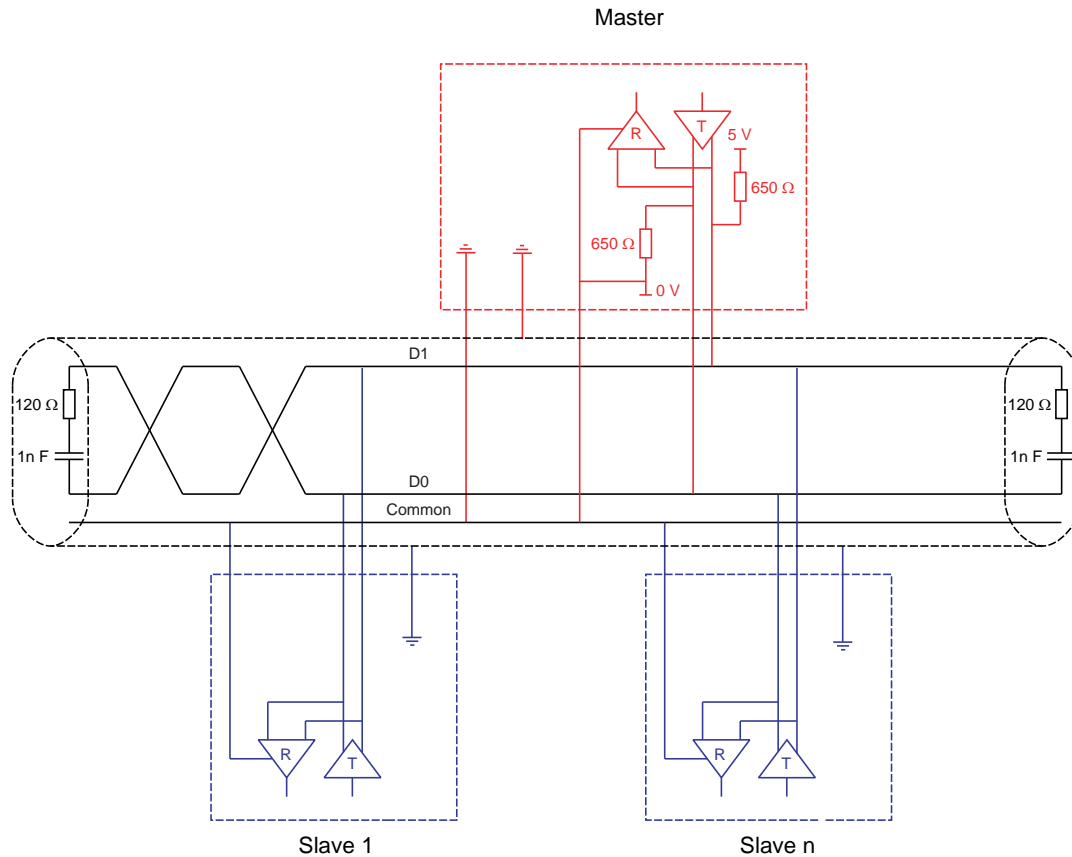
# Connection to RS485 bus

## Standard schematic

The standard schematic corresponds to the Modbus specification published on the Modbus.org site in 2002 (Modbus\_over\_serial\_line\_V1.pdf, Nov 2002) and in particular to the schematic of the 2-wire multidrop serial bus.

The ATV12 drive follows this specification.

Schematic diagram:



|   |  |
|---|--|
| Type of trunk cable                           | Shielded cable with 1 twisted pair and at least a 3 <sup>rd</sup> conductor  |
| Maximum length of bus                         | 1000 m at 19200 bps with the Schneider Electric TSX CSA●●● cable   |
| Maximum number of stations (without repeater) | 32 stations, ie. 31 slaves   |
| Maximum length of tap links                   | <ul style="list-style-type: none"> <li>• 20 m for one tap link</li> <li>• 40 m divided by the number of tap links on a multiple junction box</li> </ul>  |
| Bus polarisation                              | <ul style="list-style-type: none"> <li>• One 450 to 650 Ω pulldown resistor at 5 V (650 Ω recommended)</li> <li>• One 450 to 650 Ω pulldown resistor at the Common (650 Ω recommended)</li> </ul> This polarisation is recommended for the master. |
| Line terminator                               | One 120 Ω 0.25 W resistor in series with a 1 nF 10 V capacitor   |
| Common polarity                               | Yes (Common), connected to the protective ground at one or more points on the bus  |



