Altivar 31

User's manual

Modbus

Contents

Presentation

The Modbus socket on the Altivar 31 can be used for the following functions:

- Configuration
- Settings
- Control
- Monitoring

The ATV31 drive supports:
- The 2-wire RS485 physical layer
- The RTU transmission mode

This guide contains information on installation and describes the Modbus services available. The "communication variables" guide describes the operating modes, as well as the Altivar 31 variables and parameters which can be accessed via the communication bus.
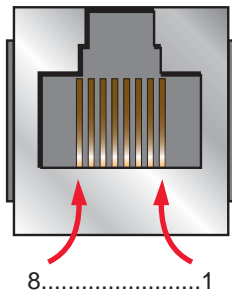
Connection to RS485 bus

Connection to ATV31

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

Connect the RJ45 cable connector to the ATV31 connector.
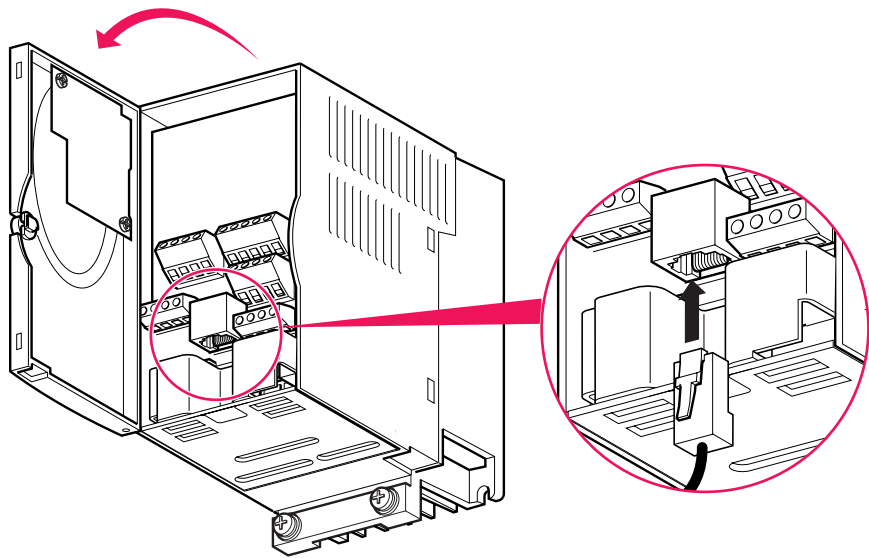
Pin out of the ATV31 RJ45 Connector

View from underneath

8........................1

Pin	Signal
1	CAN_H
2	CAN_L
3	CAN_GND
4	D1 (1)
5	D0 (1)
6	Not connected
7	VP (2)
8	Common (1)

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

Protection against interference

- Use the Telemecanique cable with 2 pairs of shielded twisted conductors (reference: TSXCSA100, TSXCSA200, TSXCSA500).
- Keep the Modbus cable from the power cables (30 cm minimum).
- Make any crossovers of the Modbus cable and the power cables at right-angles, if necessary.
- Connect the cable shielding to the ground of each device.

For more information, please refer to the TSX DG KBL E guide: "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 the next paragraph (Standard schematic). The new Telemecanique devices conform to this specification.

Some devices comply with earlier specifications. The two most widespread are described in the appendices:
- "Uni-Telway schematic" page
- "Jbus schematic" page

Requirements enabling different types of protocol to coexist are given in the appendix:
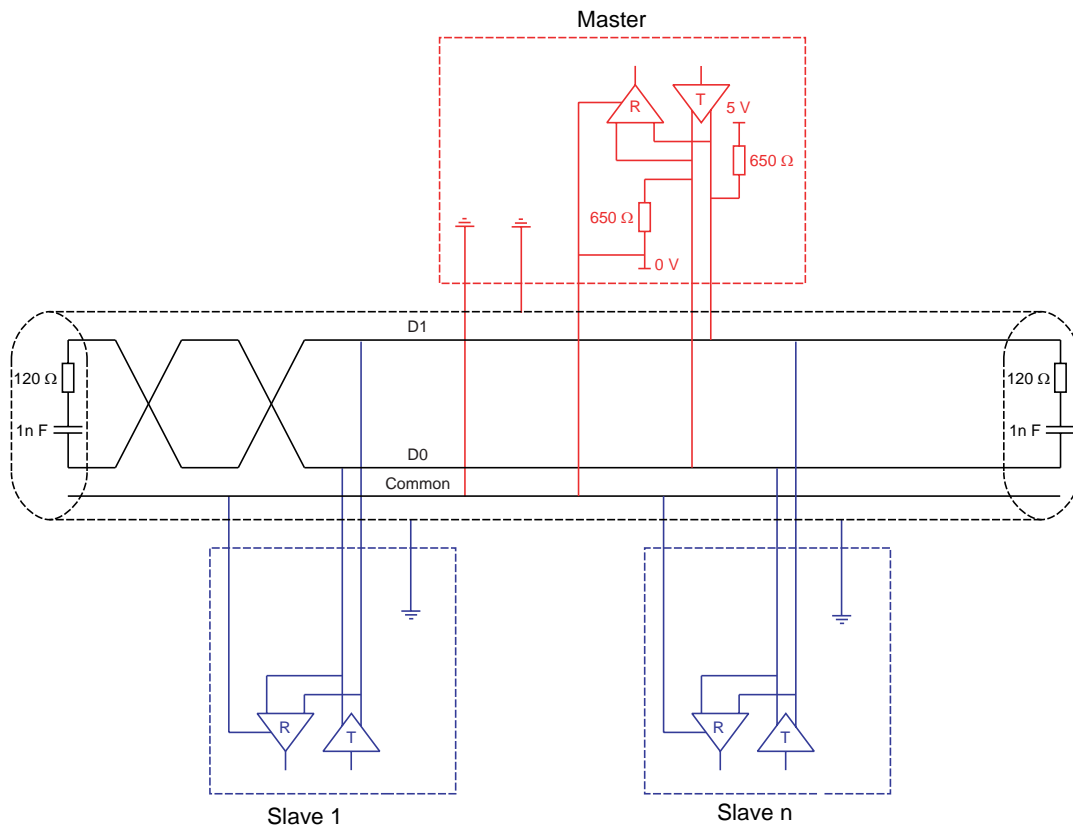- "Mixed schematic" page

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 ATV31 drive conforms to this specification.

Schematic diagram:

Type of trunk cable	Shielded cable with 1 twisted pair and at least a 3rd conductor
Maximum length of bus	1000 m at 19200 bps with the Telemecanique TSX CSA●●● cable
Maximum number of stations (without repeater)	32 stations, ie. 31 slaves
Maximum length of tap links	• 20 m for one tap link • 40 m divided by the number of tap links on a multiple junction box
Bus polarisation	• One 450 to 650 Ω pulldown resistor at 5 V (650 Ω recommended) • One 450 to 650 Ω pulldown resistor at the Common (650 Ω recommended) This polarisation is recommended for the master.
Line terminator	One 120 Ω 0.25 W resistor in series with a 1nF 10 V capacitor
Common polarity	Yes (Common), connected to the protective ground at one or more points on the bus

Connection to RS485 bus

Connection via RJ45 wiring system
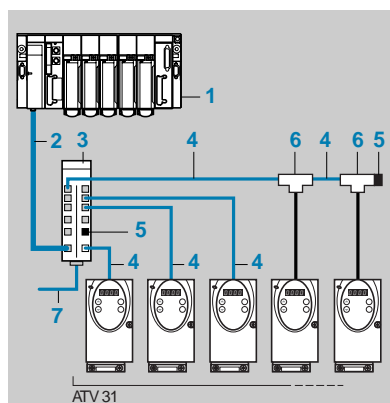
1 Master (PLC, PC or communication module)

2 Modbus cable depending on the type of master (see table)

3 Modbus splitter block **LU9 GC3**

4 Modbus drop cables **VW3 A8 306 R●●**

5 Line terminators **VW3 A8 306 RC**

6 Modbus T-junction boxes **VW3 A8 306 TF●●** (with cable)

7 Modbus cable (to another splitter block) **TSX CSA●00**

Connection accessories

| Description		Reference
Modbus splitter block	10 RJ45 connectors and 1 screw terminal	LU9 GC3
Modbus T-junction boxes	With integrated cable (0.3 m)	VW3 A8 306 TF03
	With integrated cable (1 m)	VW3 A8 306 TF10
Line terminators	For RJ45 connector	R = 120 Ω, C = 1 nF	VW3 A8 306 RC
		R = 150 Ω (specific to "Jbus schematic" page 14)	VW3 A8 306 R

Connecting cables

Description	Length m	Connectors	Reference
Cables for Modbus bus	3	1 RJ45 connector and 1 stripped end	VW3 A8 306 D30
	0.3	2 RJ45 connectors	VW3 A8 306 R03
	1	2 RJ45 connectors	VW3 A8 306 R10
	3	2 RJ45 connectors	VW3 A8 306 R30
RS 485 double shielded twisted pair cables	100	Supplied without connector	TSX CSA 100
	200	Supplied without connector	TSX CSA 200
	500	Supplied without connector	TSX CSA 500

Type of master	Master interface	Modbus connection accessories for RJ45 wiring system	
		Description	Reference
Twido PLC	Adaptor or mini-DIN RS485 interface module	3 m cable fitted with a mini-DIN connector and an RJ45 connector	TWD XCA RJ030
	Adaptor or screw terminal RS485 interface module	3 m cable fitted with an RJ45 connector and stripped at the other end	VW3 A8 306 D30
TSX Micro PLC	Mini-DIN RS485 connector port	3 m cable fitted with a mini-DIN connector and an RJ45 connector	TWD XCA RJ030
	PCMCIA card (TSX SCP114)	Stripped cable	TSX SCP CM 4030
TSX Premium PLC	TSX SCY 11601 or TSX SCY 21601 module (SUB-D 25 socket)	Cable fitted with a SUB-D 25 connector and stripped at the other end (for connection to the screw terminals of the LU9GC3 splitter block)	TSX SCY CM 6030
	PCMCIA card (TSX SCP114)	Stripped cable	TSX SCP CM 4030
Ethernet bridge (174 CEV 300 10)	Screw terminal RS485	3 m cable fitted with an RJ45 connector and stripped at the other end	VW3 A8 306 D30
Profibus DP gateway (LA9P307)	RJ45 RS485	1 m cable fitted with 2 RJ45 connectors	VW3 P07 306 R10
Fipio (LUFP1) or Profibus DP (LUFP7) or DeviceNet (LUFP9) gateway	RJ45 RS485	0.3 m cable fitted with 2 RJ45 connectors or 1 m cable fitted with 2 RJ45 connectors or 3 m cable fitted with 2 RJ45 connectors	VW3 A8 306 R03 or VW3 A8 306 R10 or VW3 A8 306 R30
Serial port PC	Male SUB-D 9 RS232 serial port PC	RS232/RS485 converter and 3 m cable fitted with an RJ45 connector and stripped at the other end (for connection to the screw terminals of the LU9GC3 splitter block)	TSX SCA 72 and VW3 A8 306 D30

Connection to RS485 bus

Connection via junction boxes
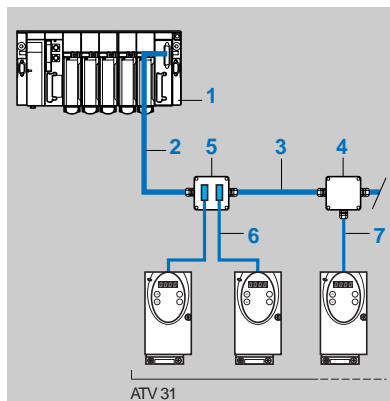
1 Master (PLC, PC or communication module)

2 Modbus cable depending on the type of master

3 Modbus cable **TSX CSA●00**

4 Junction box **TSX SCA 50**

5 Subscriber sockets **TSX SCA 62**

6 Modbus drop cables **VW3 A8 306**

7 Modbus drop cable **VW3 A8 306 D30**

Connection accessories

Description	Reference
Junction box 3 screw terminals and an RC line terminator, to be connected using cable VW3 A8 306 D30	TSX SCA 50
Subscriber socket 2 female 15-way SUB-D connectors, 2 screw terminals, and RC line terminator, to be connected using cable VW3 A8 306 or VW3 A8 306 D30	TSX SCA 62

Connecting cables

Description	Length m	Connectors	Reference
Cables for Modbus bus	3	1 RJ45 connector and one stripped end	VW3 A8 306 D30
	5	1 RJ45 connector and 1 male 15-way SUB-D connector for TSX SCA 62	VW3 A8 306
RS 485 double shielded twisted pair cables	100	Supplied without connector	TSX CSA 100
	200	Supplied without connector	TSX CSA 200
	500	Supplied without connector	TSX CSA 500

Type of master	Master interface	Modbus connection accessories for junction boxes using screw terminals	
		Description	Reference
Twido PLC	Adaptor or screw terminal RS485 interface module	Modbus cable	TSX CSA100 or TSX CSA200 or TSX CSA500
TSX Micro PLC	Mini-DIN RS485 connector port	Junction box	TSX P ACC 01
	PCMCIA card (TSX SCP114)	Cable fitted with a special connector and stripped at the other end	TSX SCP CU 4030
TSX Premium PLC	TSX SCY 11601 or TSX SCY 21601 module (SUB-D 25 socket)	Cable fitted with a SUB-D 25 connector and stripped at the other end	TSX SCY CM 6030
	PCMCIA card (TSX SCP114)	Cable fitted with a special connector and stripped at the other end	TSX SCP CU 4030
Ethernet bridge (174 CEV 300 10)	Screw terminal RS485	Modbus cable	TSX CSA100 or TSX CSA200 or TSX CSA500
Profibus DP gateway (LA9P307)	RJ45 RS485	3 m cable fitted with an RJ45 connector and stripped at the other end	VW3 A8 306 D30
Fipio (LUFP1) or Profibus DP (LUFP7) or DeviceNet (LUFP9) gateway	RJ45 RS485	3 m cable fitted with an RJ45 connector and stripped at the other end	VW3 A8 306 D30
Serial port PC	Male 9-way SUB-D RS232 serial port PC	RS232/RS485 converter and Modbus cable	TSX SCA 72 and TSX CSA100 or TSX CSA200 or TSX CSA500

Modbus protocol

Configuration of the serial link

Configuration of the serial link parameters can be accessed from the Communication menu COM-

Parameters	Possible values	Terminal display	Default value
Address Add	1 to 247	001 to 247	1
Speed tbr	4800 bps 9600 bps 19200 bps (1)	4.8 9.6 19.2	19200 bps
Format tFO	8 data bits, odd parity, 1 stop bit 8 data bits, even parity, 1 stop bit (1) 8 data bits, no parity, 1 stop bit 8 data bits, no parity, 2 stop bits	8O1 8E1 8n1 8n2	8E1

(1) The display terminal will only work with these values.

RTU mode

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

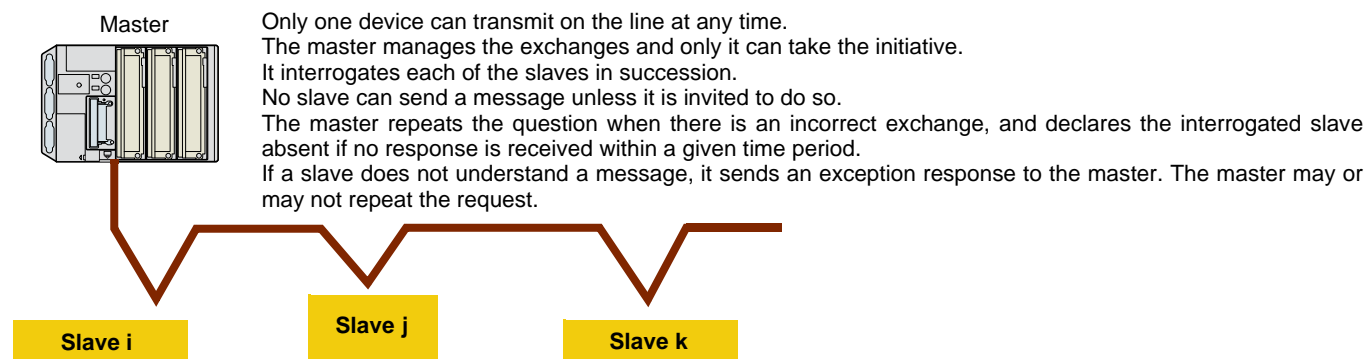| Slave address	Request code	Data	CRC16

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.

Master

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.

Slave i   Slave j   Slave k

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. ATV 31 drives take account of the request, but do not respond to it.

Modbus protocol

Modbus functions

The following table indicates which Modbus functions are managed by the Altivar 31, and specifies their limits.
The "read" and "write" functions are defined from the point of view of the master.

Code (decimal)	Function name	Broadcasting	Max. value of N	Modbus standard name
3	Read N output words	NO	29 words max.	Read Holding Registers
6	Write one output word	YES	–	Preset Single Register
16	Write N output words	YES	27 words max.	Preset Multiple Regs
43	Identification	NO	–	Read Device Identification

Read N output words: function 3

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

This function can be used to read all ATV 31 words, both input words and output words.

Request

Slave no.	03	No. of first word		Number of words		CRC16	
		Hi	Lo	Hi	Lo	Lo	Hi
1 byte	1 byte	2 bytes		2 bytes		2 bytes	

Response

Slave no.	03	Number of bytes read	First word value		-------	Last word value		CRC16	
			Hi	Lo		Hi	Lo	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	

Write one output word: function 6

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

Modbus protocol

Identification: Function 43 (16#2B)

Request

Slave no.	2B	Type of MEI 0E	ReadDeviceId 01	Object Id 00	CRC16	
					Lo	Hi
1 byte	1 byte	1 byte	1 byte	1 byte	2 bytes	

Response

Slave no.	2B	Type of MEI 0E	ReadDeviceId 01	Degree of conformity 02	-------
1 byte	1 byte	1 byte	1 byte	1 byte	

-------	Number of additional frames 00	Next object Id 00	Number of objects 03	-------
	1 byte	1 byte	1 byte	

-------	Id of object no. 1 00	Length of object no. 1 0D	Value of object no. 1 "Telemecanique"	-------
	1 byte	1 byte	13 bytes	

-------	Id of object no. 2 01	Length of object no. 2 0F	Value of object no. 2 "ATV31HU09M3S232"	-------
	1 byte	1 byte	15 bytes	

-------	Id of object no. 3 02	Length of object no. 3 04	Value of object no. 3 "0201"	-------
	1 byte	1 byte	4 bytes	

-------	CRC16	
	Lo	Hi
	1 byte	1 byte

The total response size equals 48 bytes

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

• Object no. 1:   Manufacturer name (always "Telemecanique", ie. 13 bytes).
• Object no. 2:   Device reference (ASCII string; *for example:* "ATV31HU09M3S232", ie. 15 bytes).
• Object no. 3:   Device version, in "MMmm" format where "MM" represents the determinant and "mm" the subdeterminant (4-byte 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 31 rather than the response described above.

Modbus protocol

Negative response

Slave no.	2B + 80 AB	Type of MEI 0E	Error code 00 to 02	CRC16	
				Lo	Hi
1 byte	1 byte	1 byte	1 byte	1 byte	1 byte

Error code:
- 16#00 = No error
- 16#01 = The "Request code" (16#2B), the "Type of MEI" (16#0E) or the "ReadDeviceId" (16#01) contained in the request is incorrect
- 16#02 = The "Object Id" (16#00) contained in the request is incorrect

Example: Following the request from the Modbus master, slave 2 identifies itself as follows:
- Manufacturer name = "Telemecanique" (13 bytes)
- Device name = "ATV31HU09M3S232" (15 bytes)
- Device version = "0201" (4 bytes)

Request	02	2B	0E	01	00	3477

Response	02	2B	0E	01	02	00	00	03	-------

-------	00	0D	54 45 4C 45 4D 45 43 41 4E 49 51 55 45	-------

-------	01	0F	41 54 56 33 31 48 55 30 39 4D 33 53 32 33 32	-------

-------	02	04	30 32 30 31	A80F

Write N output words: function 16 (16#10)

Request

No. slave	10	No. of first word		Number of words	Number of bytes	Value of first word		-------	CRC16	
		Hi	Lo			Hi	Lo		Lo	Hi
1 byte	1 byte	2 bytes		2 bytes	1 byte	2 bytes			2 bytes	

Response

Slave no.	10	No. of first word		Number of words		CRC16	
		Hi	Lo	Hi	Lo	Lo	Hi
1 byte	1 byte	2 bytes		2 bytes		2 bytes	

Example: write values 20 and 30 in words W4043 and W4044 in slave 2
(ACC = 20 s and DEC = 30 s)

Request	02	10	0FCB	0002	04	0014	001E	30F4

Response	02	10	0FCB	0002	3311

Modbus protocol

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).
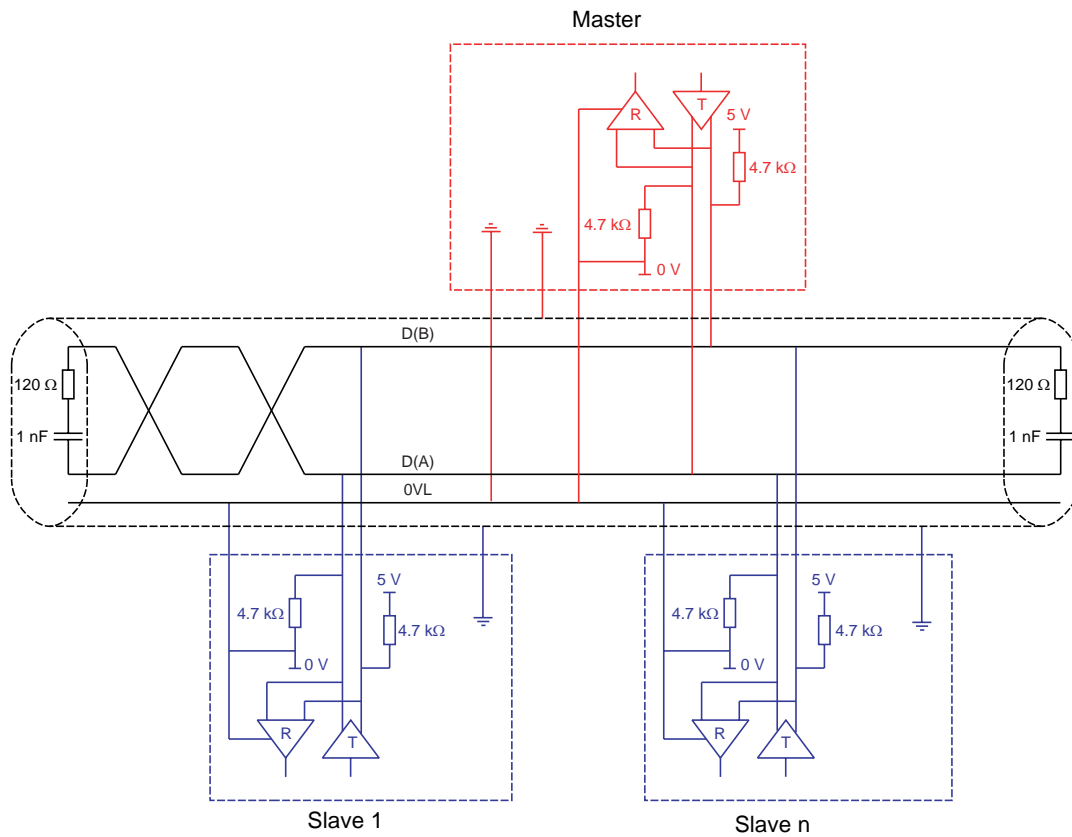
XOR = exclusive OR.

Appendix: Non-standard RS485 schematics

Uni-Telway schematic

The Uni-Telway bus schematic has been used by Telemecanique for its drives and soft starters (ATV58, ATV28, etc).
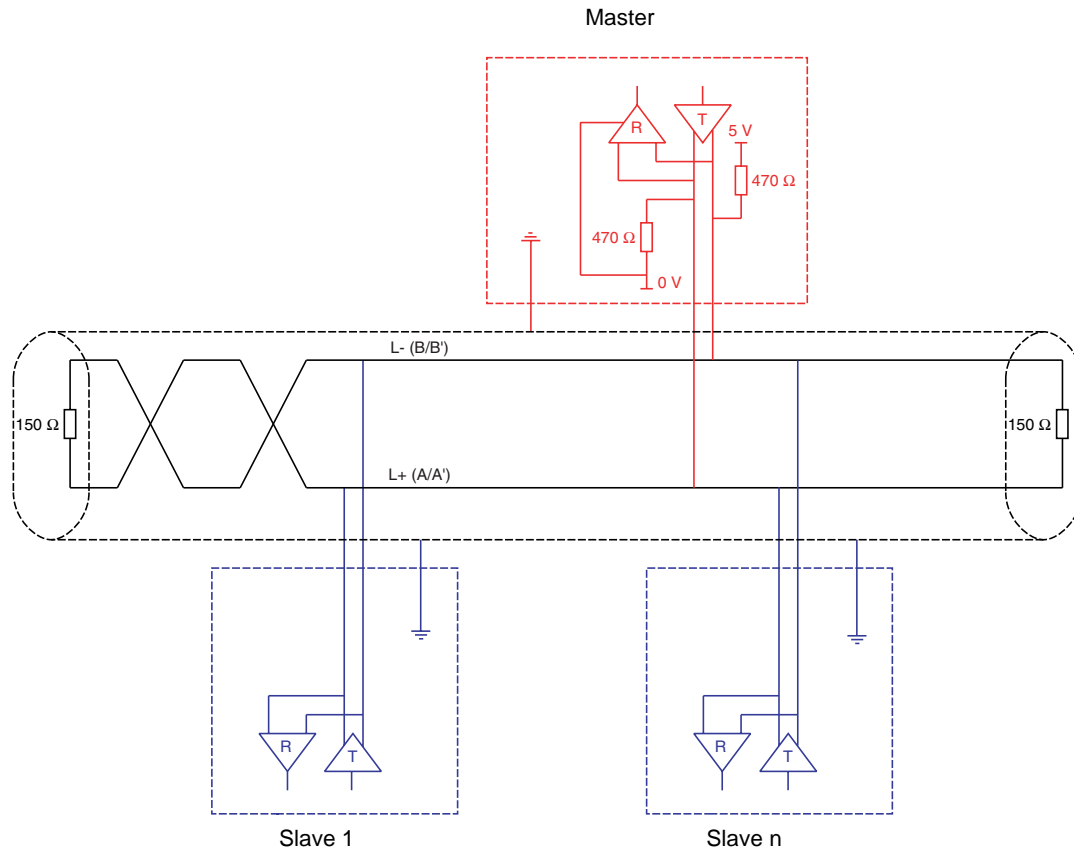
Schematic diagram:

Type of trunk cable	Cable with 2 twisted pairs shielded in pairs
Maximum length of bus	1000 m at 19200 bps
Maximum number of stations (without repeater)	29 stations, ie. 28 slaves
Maximum length of tap links	• 20 m • 40 m divided by the number of tap links on a multiple junction box
Bus polarisation	For the master and each slave: • One 4.7 kΩ pulldown resistor at 5 V • One 4.7 kΩ pulldown resistor at 0 VL
Line terminator	One 120 Ω 0.25 W resistor in series with a 1 nF 10 V capacitor
Common polarity	Yes (0 VL) and high impedance placed between 0 VL and the ground in each station

Appendix: Non-standard RS485 schematics
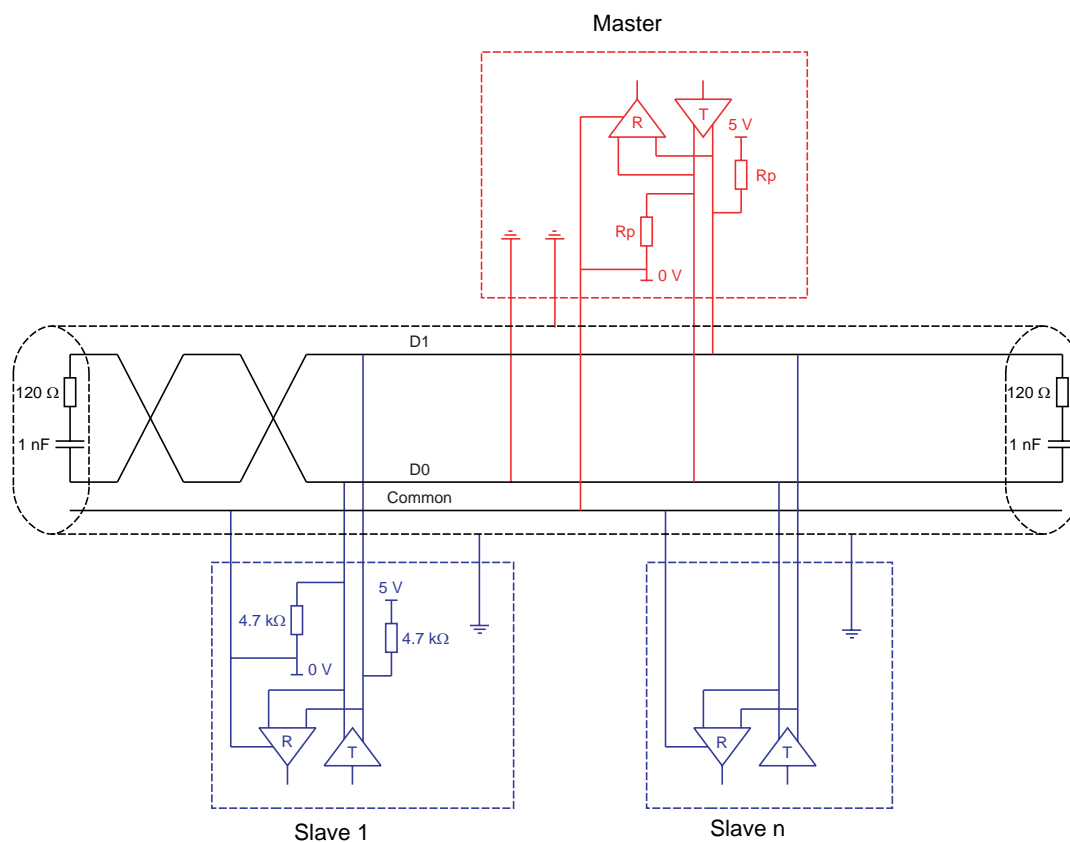
Jbus schematic

Schematic diagram:

Master

L- (B/B')

L+ (A/A')

150 Ω

150 Ω

5 V

470 Ω

470 Ω

0 V

R   T

R   T

R   T

Slave 1

Slave n

Type of trunk cable	Cable with 1 shielded twisted pair
Maximum length of bus	1300 m at 19200 bps
Maximum number of stations (without repeater)	32 stations, ie. 31 slaves
Maximum length of tap links	3 m
Bus polarisation	One 470 Ω pulldown resistor at 5 V One 470 Ω pulldown resistor at 0 V This polarisation is often provided in the master.
Line terminator	One 150 Ω resistor
Common polarity	No

Appendix: Non-standard RS485 schematics

Mixed schematic

Slaves with 4.7 kΩ polarisation can be integrated into a standard schematic. Suitable polarisation (Rp) must be calculated.

Schematic diagram:

Type of trunk cable	Shielded cable with 1 twisted pair and at least a 3rd conductor
Maximum length of bus	1000 m at 19200 bps
Maximum number of stations (without repeater)	At most 32 stations ie. 31 slaves (depending on Rp and the number of 4.7 kΩ resistors)
Maximum length of tap links	• 20 m for a single tap link • 40 m divided by the number of tap links on a multiple junction box
Bus polarisation	• One pulldown resistor at 5 V (Rp) • One pulldown resistor at the Common (Rp) This polarisation can be provided in the master. The value of Rp should be validated (or determined) by calculating the equivalent polarisation (Re) according to the polarisation of the master and slave stations. The value of Re must be between 162 Ω and 650 Ω (recommended value: 650 Ω).
Line terminator	One 120 Ω 0.25 W resistor in series with a 1 nF 10 V capacitor
Common polarity	Yes (Common)

• To calculate the polarisation (Rp), all station polarisations must be deemed to be connected in parallel.

Example:
If the bus Rp polarisation is 470 Ω (installed in the master) and 2 slaves have 4700 Ω polarisation, the equivalent polarisation is:
$1/Re = 1/470 + 1/4700 + 1/4700$
ie. $Re = 1/ (1/470 + 1/4700 + 1/4700)$
and therefore $Re = 390\ \Omega$.
390 Ω is greater than 162 Ω, and the schematic is correct.

For an ideal equivalent polarisation (650 Ω), Rp bus polarisation can be installed so that:
$1/650 = 1/Rp + 1/4700 + 1/4700$
ie. $Rp = 1/(1/650 - 1/4700 - 1/4700)$
and therefore $Rp = 587\ \Omega$.

• If the master is fitted with a 470 Ω polarisation, it is possible to connect a maximum of 18 slaves with 4.7 kΩ polarisation.

Appendix: Non-standard RS485 schematics

Recommendations for setting up a Modbus network using non-standard devices

1. Identify polarities D0 and D1.
   They are labeled in a variety of ways according to the specification used:

Modbus	D0	D1	Common
EIA/TIA-485	A / A'	B / B'	C / C'
UNI-TELWAY	D(A)	D(B)	0VL
Jbus	RD + / TD + L +	RD - / TD - L -	

   However, certain RS485 electronic components are labeled in the opposite way to the EIA/TIA-485 standard.
   It may be necessary to perform a test by connecting a master to a slave, then reversing the connection in the event of failure.

2. Check polarizations.
   Study the documentation supplied with the devices to determine the polarization resistance.
   If there is one, check that the value is correct (see Mixed schematic page)

   Polarization is not always possible. For example, in the event of the 5 V not being available in the master.

3. Select a line terminator.
   In the case of polarization, select an RC line terminator (R = 120 Ω, C = 1 nF).
   If polarization is not possible, select an R line terminator (R = 150 Ω).