BRIO

EN50155 Basic Remote I/O module

Application note
BRIO Extension & Ethernet redundancy

P DOC BRIO 101E V01

Leroy Automation - Axseam Group
35 Bld du Libre Echange
ZAC des Champs Pinsons
31650 Saint Orens / Toulouse France
E-mail : sales@leroy-autom.com
Web site : www.leroy-automation.com

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Introduction

BRIO is an Ethernet-based decentralized-remote input/output module designed to be embedded onboard rolling stock vehicles.

BRIO is fully compliant with the EN50155 standard for railway systems.

This application note describes all the necessary information to getting started with 2 BRIO with extension & Ethernet redundancy functionalities: hardware & software settings.

Following User Manual for BRIO are available:

- ✓ User Manual "Hardware specifications & installation" P_DOC_BRIO_002E
- ✓ User Manual "Getting Started Software Guide" reference P_DOC_BRIO_003E

Prerequisites

It is necessary that the user has got technical knowledge in mechanical & electrical railway systems.

Safety instructions

Following symbols are used in this documentation in order to avoid user for potential risks:


Risk of personal injury or damage to the equipment.


Risk of an electrical hazard.

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Contact

✉ Leroy Automation
35 Boulevard du Libre Echange
31650 SAINT-ORENS
FRANCE

☎ +33 562 240 550

+33 562 240 555

mailto:sales@leroy-autom.com

http://www.leroy-automation.com

support technique :

☎ +33 562 240 546

mailto:support@leroy-autom.com

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Chapter

1

Introduction

Contents

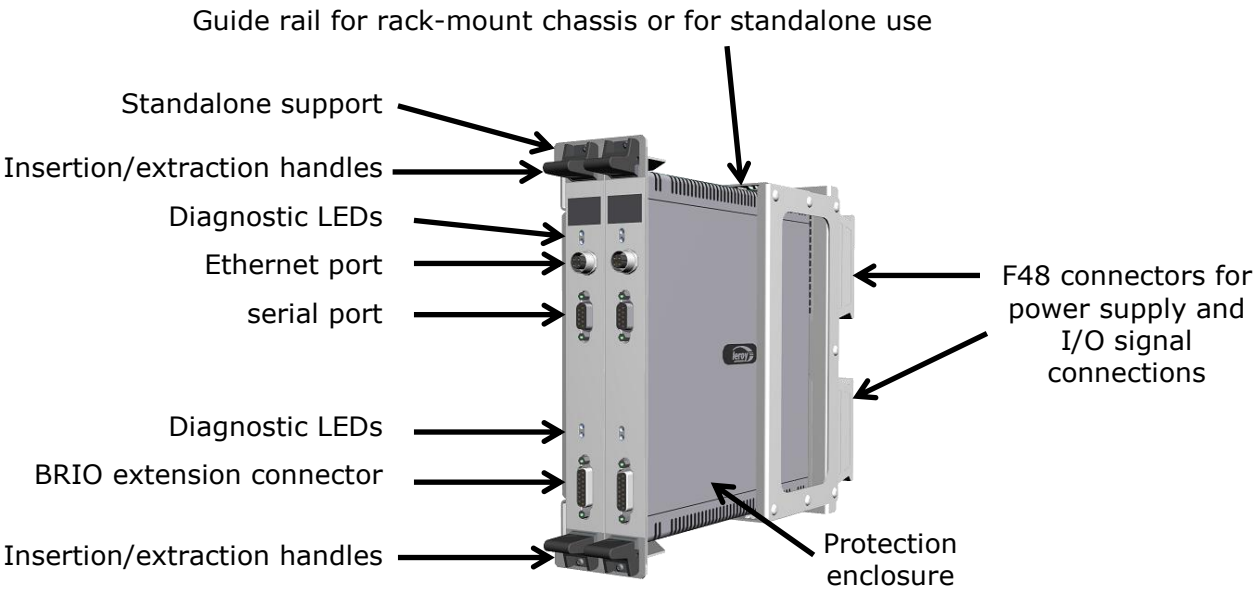
In this section, we will discuss the following topics:

- Hardware description,
- Product part numbers,
- System architecture examples,
- Features

Description

BRIO is a hardware unit fully compliant with the EN50155 standard, and it is designed to be integrated in embedded railway systems and subsystems.

The system is composed by 2 BRIO R001, in order to manage redundancy on Ethernet communications.

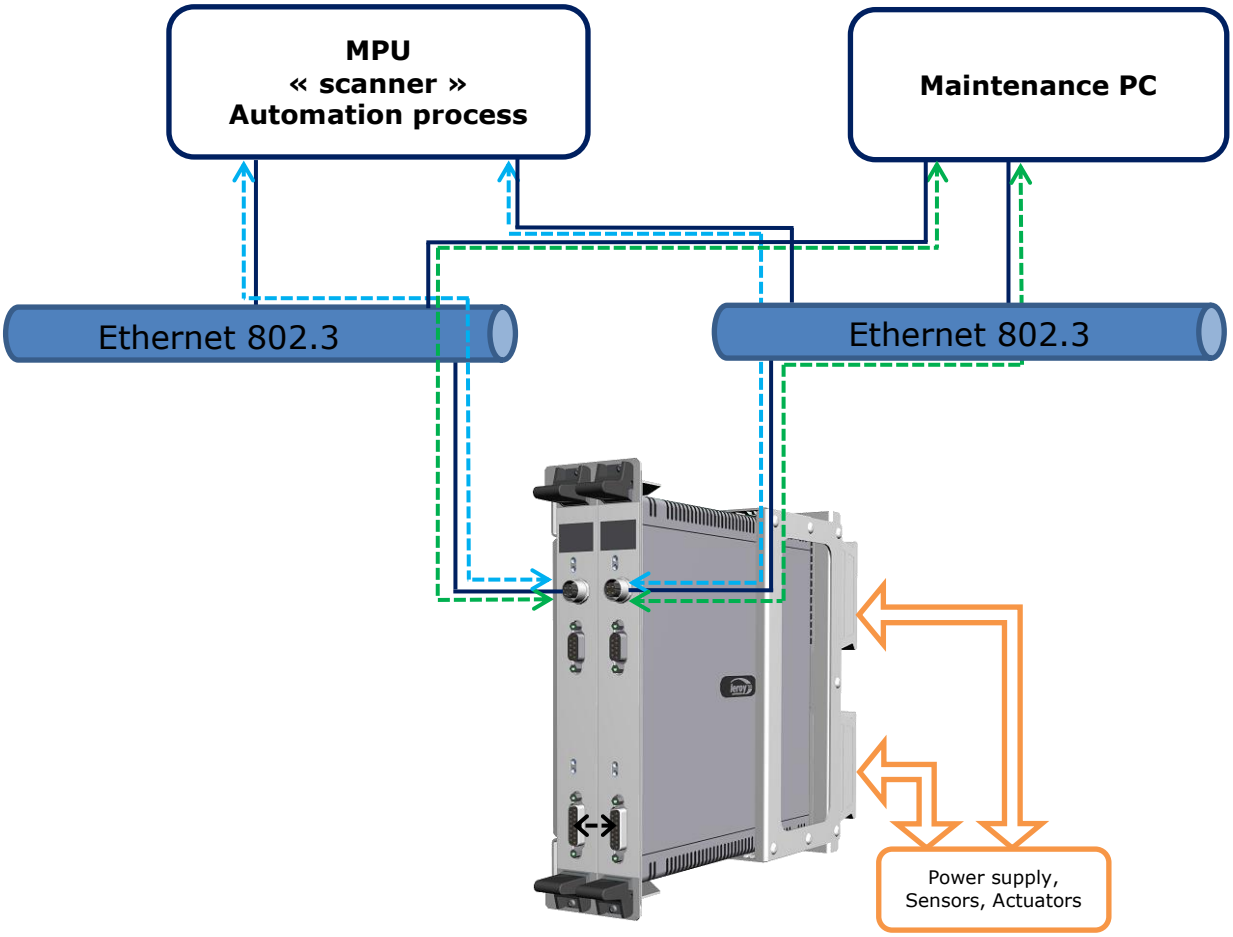


Product part numbers

Power supply	**Full range from 24V to 110VDC**
Digital inputs	**2 x 40**
Digital outputs	**2 x (8 Relays & 2 Solid State Relays (SSR))**
Analog inputs	**-**
Analog outputs	**-**
Ethernet port	**2 x IEEE 802.3 10/100Mbits/s base Tx**

System architecture example

BRIO may be used as an EtherNet/IP device « adapter » or trough UDP communication; it will then be controlled by an Ethernet/IP device « scanner » through the Ethernet network; a device « scanner » is able to read the state of the input signals, and to drive its output signals.



EIP or UDP communication path
Maintenance communication path
BRIO extension connection

Features

Variable power supply range from 24V to 110VDC

80 Digital inputs

- ✓ Variable power supply (full range from 24V to 110VDC)
- ✓ logical levels defined by software settings
- ✓ Individual filter parameters configurable
- ✓ 10mA fritting current
- ✓ Permanent auto-test on each input

20 Digital outputs

- ✓ SPDT (Single Pole Double Throw) type: relay outputs
- ✓ SSR (Solid state relay): isolated solid state ouputs, up-stream or down-stream loads, current monitoring on one output (optional)
- ✓ Command read-back feature on each output (optional)

Input/Output management implemented in an FPGA device

STM32 ARM Cortex-M3 microcontroller with FreeRTOS real time operating system

Maximum delay between Ethernet and I/O:

- ✓ Between digital or analog inputs and Ethernet <10ms
- ✓ Between Ethernet and digital or analog outputs <15ms

Ethernet protocols available:

- ✓ EtherNet/IP adapter
- ✓ UDP protocol

BRIO too includes internal safety features as:

- ✓ a watchdog for monitoring the data communication between FPGA and microcontroller.
- ✓ a watchdog on the microcontroller.
- ✓ a safe communication (HDLC) between FPGA and microcontroller.

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Chapter

2

Communication protocols

Contents

In this section, we will discuss the following topics:

- EtherNet/IP Protocol
- UDP Protocol

EtherNet/IP Protocol

EtherNet/IP objects for Ethernet redundancy

Following instances have been added in order to manage BRIO configuration with extension; for other EIP objects, refer to User Manual "Getting Started Software Guide" P_DOC_BRIO_003E Chapter 3.

Instance number	Byte number	Bit number in the Byte word							
		7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
102	0	DI8	DI7	DI6	DI5	DI4	DI3	DI2	DI1
	1	DI16	DI15	DI14	DI13	DI12	DI11	DI10	DI9
	2	DI24	DI23	DI22	DI21	DI20	DI19	DI18	DI17
	3	DI32	DI31	DI30	DI29	DI28	DI27	DI26	DI25
	4	DI40	DI39	DI38	DI37	DI36	DI35	DI34	DI33
	5	DI48	DI47	DI46	DI45	DI44	DI43	DI42	DI41
	6	DI56	DI55	DI54	DI53	DI52	DI51	DI50	DI49
	7	DI64	DI63	DI62	DI61	DI60	DI59	DI58	DI57
	8	DI72	DI71	DI70	DI69	DI68	DI67	DI66	DI65
	9	DI80	DI79	DI78	DI77	DI76	DI75	DI74	DI73
	--	--	--	--	--	--	--	--	--
	20	DIs8	DIs7	DIs6	DIs5	DIs4	DIs3	DIs2	DIs1
	21	DIs16	DIs15	DIs14	DIs13	DIs12	DIs11	DIs10	DIs9
	22	DIs24	DIs23	DIs22	DIs21	DIs20	DIs19	DIs18	DIs17
	23	DIs32	DIs31	DIs30	DIs29	DIs28	DIs27	DIs26	DIs25
	24	DIs40	DIs39	DIs38	DIs37	DIs36	DIs35	DIs34	DIs33
	25	DIs48	DIs47	DIs46	DIs45	DIs44	DIs43	DIs42	DIs41
	26	DIs56	DIs55	DIs54	DIs53	DIs52	DIs51	DIs50	DIs49
	27	DIs64	DIs63	DIs62	DIs61	DIs60	DIs59	DIs58	DIs57
	28	DIs72	DIs71	DIs70	DIs69	DIs68	DIs67	DIs66	DIs65
	29	DIs80	DIs79	DIs78	DIs77	DIs76	DIs75	DIs74	DIs73
	--	--	--	--	--	--	--	--	--
	40	DOs8	DOs7	DOs6	DOs5	DOs4	DOs3	DOs2	DOs1
	41	DOs16	DOs15	DOs14	DOs13	DOs12	DOs11	DOs10	DOs9
	42	--	--	--	--	DOs20	DOs19	DOs18	DOs17
	--	--	--	--	--	--	--	--	--
103	0	DO8	DO7	DO6	DO5	DO4	DO3	DO2	DO1
	1	DO16	DO15	DO14	DO13	DO12	DO11	DO10	DO9
	2	--	--	--	--	DO20	DO19	DO18	DO17
104	0	reserved	reserved	reserved	reserved	reserved	reserved	Digital Input Threshold	
	1	Scanner monitoring timeout							

With:

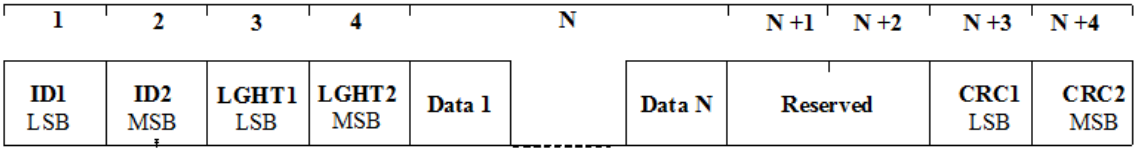
- DIx: Value of the filtered TOR input # x; the filtering function is defined according to the value « DIx filter » in the configuration assembly; (DI=Digital Input).
- AIx: Value of the analog input # x in points (AI=Analog Input):
  - Voltage inputs (AI1 and AI2): ±10,312V <-> -32768/+32767 points
  - Current inputs (AI3 and AI4): ±22,12mA <-> -32768/+32767 points
- DIsx, DOsx, AIsx, AOs1: Status value of each input (DIx or AIx) or output (DOx or AO1):
  - 0= correct operational mode
  - 1= defect/fault
- DOx: Command value of the TOR output # x (DO=Digital Output).
- AOx: Command value of the analog output # x:
  - Current output (AO1_I): 0-32767 points <-> 0-20mA
  - Voltage output (AO1_U): 0-32767 points <-> 0-10V
- Digital Input Threshold: value 0, 1 or 2 (24Vdc, 72Vdc or 110Vdc)
- Scanner monitoring timeout: value between 0 and 255, unit 10ms (timeout between 0ms and 2550ms).

UDP-based proprietary protocol

Principles

The protocol used is request/response type based on UDP: the BRIO device responds to requests of another device connected on the Ethernet network.

The data threads exchanged on this UDP protocol are defined as it follows:



ID : Frame ID.
LGHT : Frame length = N
Data : data
CRC : 16 bits CRC
Reserved : Alignment crc on 32 bits.

Available functions

A large number of functions are available to set, to maintain and to control the BRIO device. For this application, only function code 0x03 & 0x11 are used.

Request			Response of BRIO	
Code	**Type**	**Description**	**Code**	**Description**
0x01	Read	BRIO configuration	0x21	Returns the BRIO configuration settings
0x02	Read	Events log	0x22	Returns the events log
0x03	Read	Values and status of inputs/outputs, and auto-tests results	0x23	Returns the values and status of inputs/outputs, and auto-tests results
0x04	Read	Filtering values of digital inputs	0x24	Returns the filtering values of digital inputs
0x05	Read	Digital output configuration	0x25	Returns the digital output configuration
0x06	Read	Analog outputs configuration	0x26	Returns the analog outputs configuration
0x07	Read	KID settings	0x27	Returns the KID settings
0x10	Write	Filtering values of digital inputs	0x30	Returns the write status
0x11	Write	Digital and analogs outputs	0x31	Returns the write status
0x12	Write	IP configuration from the BRIO internal memory	0x32	Returns the write status
0x15	Write	Digital output properties from the BRIO internal memory	0x35	Returns the write status

0x16	Write	Analog output properties from the BRIO internal memory	Ox36	Returns the write status
0x17	Write	KID settings	0x37	Returns the write status
0x18	Write	Ethernet configuration from the BRIO internal memory	0x38	Returns the write status
0xAB	Command	BRIO reset		No returns

BRIO's input/output and status read command (0x03)

Request word description:

Name	Offset	Size (byte)	Value	Description
ID	0x00	2	0x03	Request ID code
LENGTH	0x02	2	0x02	Length
RESERVED	0x04	2	0	Reserved
CRC	0x06	2	0	Reserved

Response word description (BRIO):

	Name	Offset	Size (byte)	Value	Description
ID		0x00	2	0x23	Request ID code
LENGTH		0x02	2	0xD8	Length
Data	DISCRETE_IN_VALUE	0x04	20	-	Value of digital inputs Bit x of Byte y = input value number (8∗y+x+1): 0=OFF, 1=ON Byte 0 = bit0 to bit7: values of BRIO 1 digital input 1 to 8. - - - - - - - - - - - - - - - Byte 4 = bit32 to bit39: values of BRIO 1 digital input 33 to 40. Byte 5 = bit0 to bit7: values of BRIO 2 digital input 1 to 8. - - - - - - - - - - - - - - - Byte 9 = bit32 to bit39: values of BRIO 2 digital input 33 to 40. - - - - - - - - - - - - - - -
	DISCRETE_IN_STATUS	0x18	20	-	Status of digital inputs Bit x of Byte y = status of input number (8∗y+x+1): 0=OK, 1=default. Byte 0 = bit0 to bit7: status of BRIO 1 digital input 1 to 8. - - - - - - - - - - - - - - - Byte 4 = bit32 to bit39: status of BRIO 1 digital input 33 to 40. Byte 5 = bit0 to bit7: status of BRIO 2 digital input 1 to 8. - - - - - - - - - - - - - - - Byte 9 = bit32 to bit39: status of BRIO 2 digital input 33 to 40. - - - - - - - - - - - - - - -
	DISCRETE_OUT_VALUE	0x2C	8	-	Value of digital outputs Bit x of Byte y = value of output number (8∗y+x+1): 0 = OFF, 1 = ON. Byte 0= bit0 to bit 7: value of BRIO 1 digital outputs 1 à 8 Byte 1= bit0 to bit 1: value of BRIO 1 digital outputs 9 à 10 Byte 2= bit0 to bit 7: value of BRIO 2 digital outputs 1 à 8 Byte 3= bit0 to bit 1: value of BRIO 2 digital outputs 9 à 10 - - - - - - - - - - - - - - -
	DISCRETE_OUT_STATUS	0x34	8	-	Status of digital outputs Bit x of Byte y = status of output number (8∗y+x+1): 0=OK, 1=default. Byte 0= bit0 to bit 7: status of BRIO 1 digital outputs 1 à 8 Byte 1= bit0 to bit 1: status of BRIO 1 digital outputs 9 à 10 Byte 2= bit0 to bit 7: status of BRIO 2 digital outputs 1 à 8 Byte 3= bit0 to bit 1: status of BRIO 2 digital outputs 9 à 10 - - - - - - - - - - - - - - -
	reserved	0x3C	40	-	reserved
	PBIT_RESULT	0x64	2	-	Start-up test results (refer to chapter 2) Byte0 = [ROM_DEF(bit0), RAM_DEF, NVM_DEF, FPGA_DEF, TEMP_DEF, ETHER_DEF, KID _DEF, EXT_CONF_DEF (bit7)] Byte1 = [MOD_TYPE_DEF(bit0), FACTORY_DEF, res, res, res, res, res,res(bit7)]
	CBIT_RESULT	0x66	2	-	Continuous tests results (refer to chapter 2) Byte0 = [CPU_DEF(bit0), FPGA_DEF, ETHER_DEF, TEMP_DEF, EIP_DEF, DISC_IN_DEF, DISC_OUT_DEF,ANA_IN_DEF(bit7)] Byte1 = [ANA_OUT_DEF(bit0), res, res, res, res, res, res,res(bit7)]
	IBIT_RESULT	0x68	2	-	Tests results on request (refer to chapter 2) Byte0 = [RAM_DEF(bit0), res, res, res, res, res, res, res (bit7)] Byte1 = [res (bit0), res, res, res, res, res, res,res(bit7)]

	CONNECTION_EIP_STATE	0xDA	1	-	1 = EIP connection enabled 2 = no EIP connection
	Reserved	0xDB	1	0	
RESERVED		0xDC	2	0	Reserved
CRC		0xDE	2	0	Reserved

Output value write command (0x11)

Request word description:

Name		Offset	Size (byte)	Value	Description
ID		0x00	2	0x11	Request ID code
LENGTH		0x02	2	0x10	Length
Data	CMD	0x04	4	-	0x00 = digital and analog output write 0x01 = digital output write 0x02 = analog output write
	DISCRETE_OUT_VALUE	0x08	8	-	Value of 10 digital outputs is contained in 2 bytes Bit x of Byte y = output value number (8∗y+x+1): 0 = OFF, 1 = ON. Byte0 = bit0 to bit 7: value of digital outputs 1 to 8 Byte1 = bit0 to bit 1: value of digital outputs 9 to 10 BRIO 1 : offset 8 & 9 BRIO 2 : offset A & B
	ANALOG_OUTPUT_VALUE	0x10	4		Analog output value to write Byte0- Byte1 = value of analog output 1
RESERVED		0x14	2	0	Reserved
CRC		0x16	2	0	Reserved

Response word description (BRIO):

Name	Offset	Size (byte)	Value	Description
ID	0x00	2	0x31	Request ID code
LENGTH	0x02	2	0x04	Length
STATUS	0x04	4	0	0 = write completed 1 = write failure
RESERVED	0x08	2	0	Reserved
CRC	0x0A	2	0	Reserved

Chapter

3

Installation-wiring-settings

Contents

In this section, we will discuss the following topics:

- Installation
- Wiring
- Settings

Installation

BRIO shall be mounted on the standalone double support designed for it.

It receives F48 connectors for power supply and IO on the rear panel.

For mounting or dismounting, refer to User Manual "Hardware specifications & installation" P_DOC_BRIO_002E Chapter 4.

Wiring

F48, M12 & subD9 connector pinout

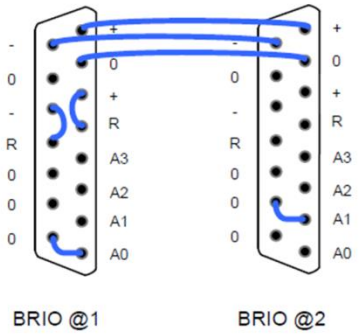
Pinout is described in P_DOC_BRIO_002E documentation Chapter3.

SubD15 connector pinout : direct connection between BRIO 1 & BRIO 2

Both BRIO shall have a direct connection between them. This direct connection is done through each BRIO SubD15 connector.

This connection is used:

- to exchange data
- to fix an address to each BRIO on this local network: then the subD15 connectors shall not be reversed.



BRIO Settings

Settings are saved in BRIO NVM (Non Volatile Memory).

They can be set or modified through BRIO subD9 RS232 link: refer to User Manuel Getting Started Software Guide P_DOC_BRIO_003E Chapter 5.

Use command "j" then command "a" in order to read all NVM settings.
Some settings are different between BRIO 1 and BRIO 2:

BRIO 1 NVM configuration:

```
NVM configuration menu
-----------------------------------------------
IP address                                    : 192.168.1.101
Netmask address                               : 255.255.255.0
Gateway address                               : 192.168.1.1
Ether config: Auto-negotiation(1=true,0=false) : 1
Ether config: Speed(0=10Mb/s,1=100Mb/s)       : 0
Ether config: Type(0=half,1=full)             : 0
Dhcp(0=no,1=yes)                              : 0
Option 61(0=no,1=yes)                         : 1
Hostname                                      : BRIO EIP
Time-out scanner(0..255)                      : 50
Analog input threshold(0=24V,1=72v,2=110V)    : 0
Extension number(0..3)                        : 1
Extension number with analog(0..2)            : 0
Module type(0=master,1=slave)                 : 0
```

BRIO 2 NVM configuration:

```
NVM configuration menu
-----------------------------------------------
IP address                                    : 192.168.2.102
Netmask address                               : 255.255.255.0
Gateway address                               : 192.168.1.1
Ether config: Auto-negotiation(1=true,0=false) : 1
Ether config: Speed(0=10Mb/s,1=100Mb/s)       : 0
Ether config: Type(0=half,1=full)             : 0
Dhcp(0=no,1=yes)                              : 0
Option 61(0=no,1=yes)                         : 1
Hostname                                      : BRIO EIP
Time-out scanner(0..255)                      : 50
Analog input threshold(0=24V,1=72v,2=110V)    : 0
Extension number(0..3)                        : 1
Extension number with analog(0..2)            : 0
Module type(0=master,1=slave)                 : 1
```

Differences are as following:

- "IP address":
  - BRIO 1 is set to 192.168.1.101
  - BRIO 2 is set to 192.168.2.102
- "Module type":
  - BRIO 1 is set to "0" (master): master shall have address 1 coded in its connected subD15.
  - BRIO 2 is set to "1" (slave): slave shall have address 2 coded in its connected subD15.

Chapter

4

Monitoring examples

Contents

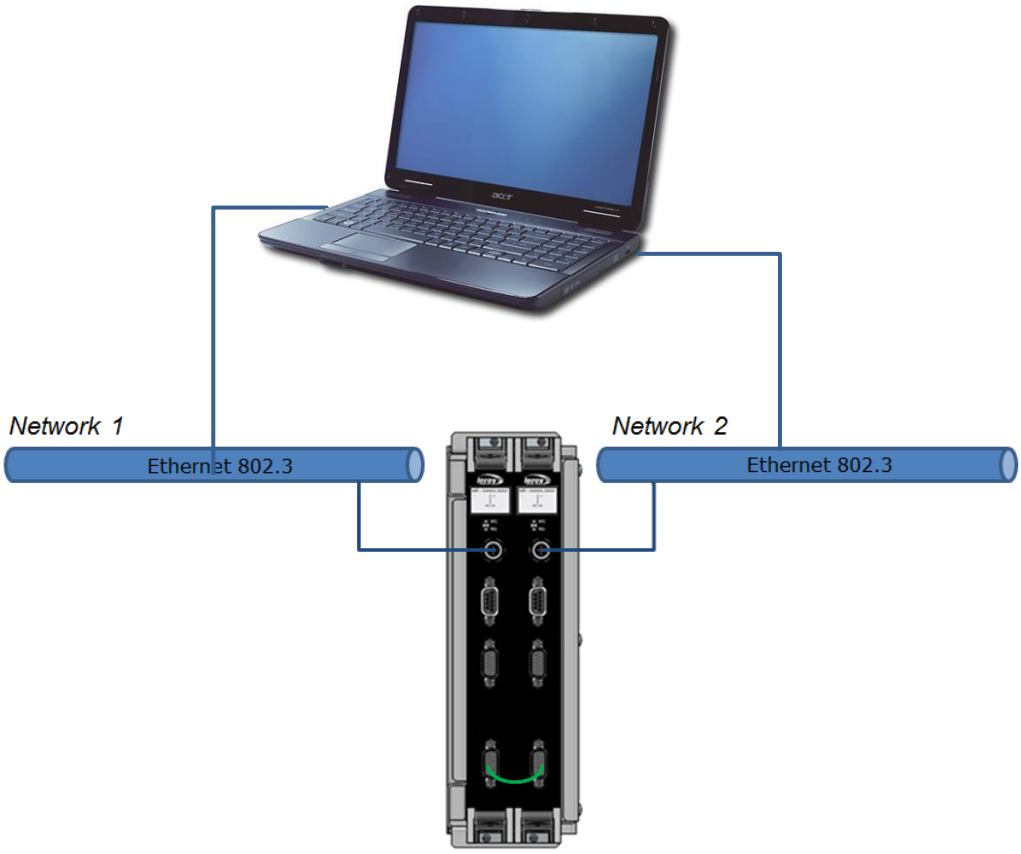
In this section, we will discuss the following topics:

- Principle
- Software Installation
- EtherNet/IP scanner
- UDP manager

Principle

Each BRIO will communicate with one PC through one Ethernet network.
For this, the PC will be fitted with:

- Specific hardware: 2 Ethernet ports, configured as following:
  - First Ethernet port: IP address 192.168.1.10
  - Second Ethernet port: IP address 192.168.2.10
- Specific Software: T5 runtime for Windows PC from the Copalp Company: this runtime will run projects developed with "STRATON" (IEC61131 IDE from Copalp).



2 projects have been developed with STRATON IDE in order to test both communication types (EtherNet/IP & UDP).

Software Installation

We need to install several softwares on the PC:

- T5 runtime
- STRATON IDE

After STRATON installation, we will restore in STRATON the BRIO2E list of projects developed for these tests.

Copalp T5 runtime setup

Execute the following setup file "STRATON.T5.setup.8.7.build.2.exe". This software is protected, but you can run it for demonstrations during 15 minutes. If you need more, you have to stop & start it.

STRATON IDE setup

Execute the following setup file "STRATON.IDE.setup.8.7.build.2.exe". This software is protected, but for demonstrations you can run it and build projects containing less 40 IO variables.

STRATON Project List

The complete project list is contained in a zip file: "BRIO2E.zip"

- "BRIO2E_EIP1": project with EtherNet/IP communication.
- "BRIO2E_UDP1": project with UDP communication.

In STRATON Editor 8.7 (IDE), select menu "File"/"Open Project List"/"From Zip": select the zip file: "BRIO2E.zip", and validate.

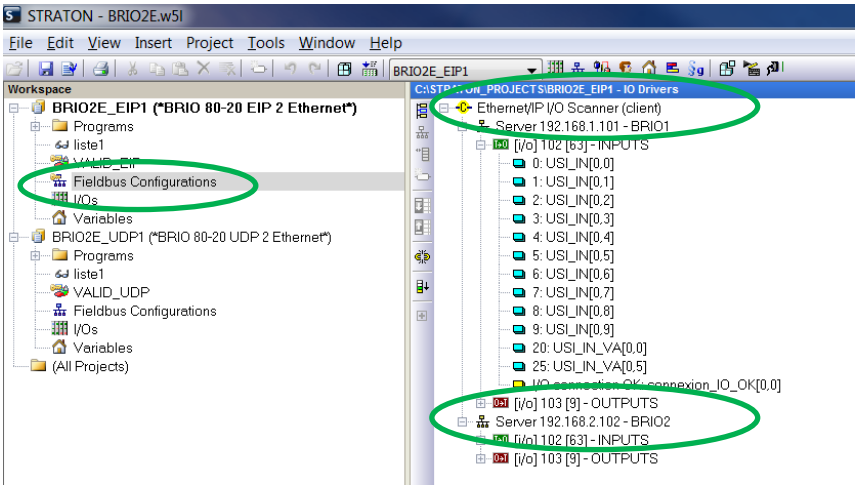
EtherNet/IP scanner

Principle

The project "BRIO2E_EIP1" enables 1 EtherNet/IP connection with each BRIO:

Configuration

The fieldbus Configurations tool allows to define the complete EtherNet/IP communication on both Ethernet networks with all project variables linked to:

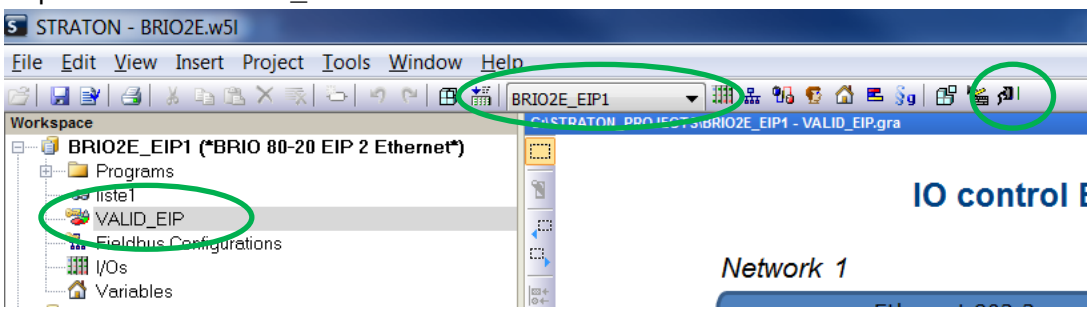


Test

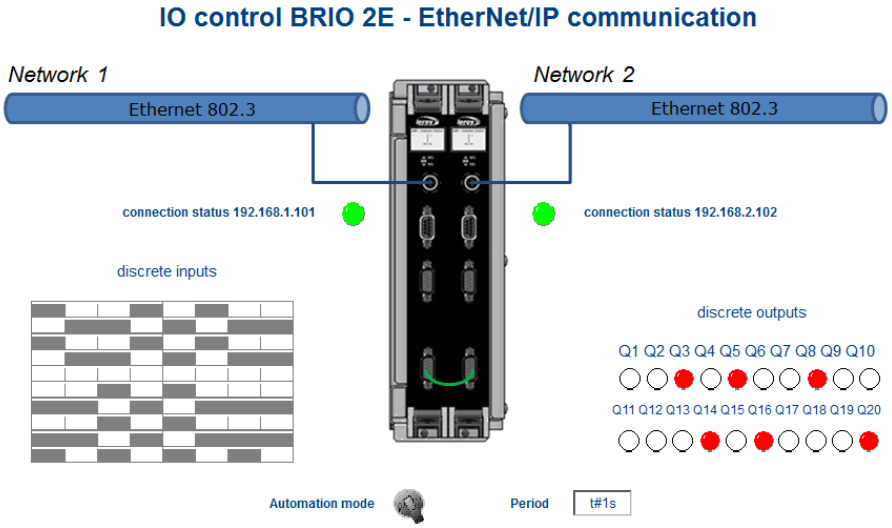
The project BRIO2E_EIP1 shall have been selected, then:

- connect you to the T5 Runtime with the "On line" button
- download the project code into the T5 runtime

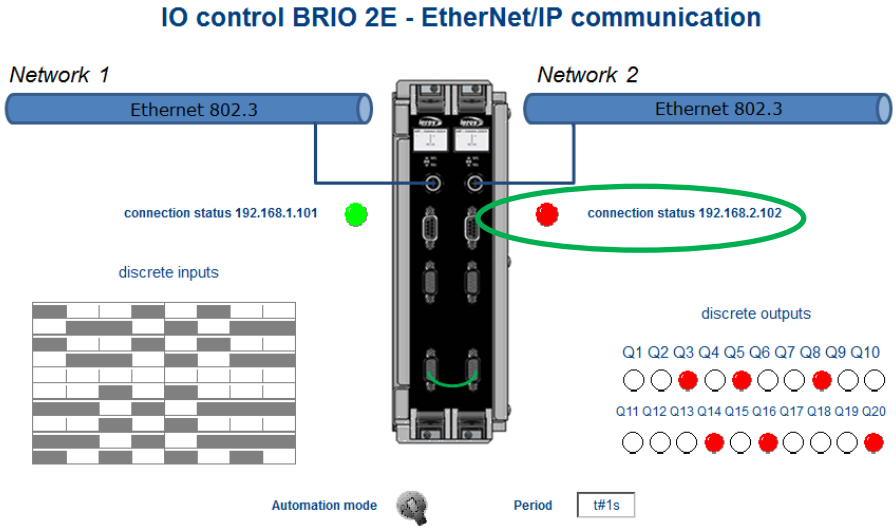
The Graphic window "Valid_EIP" allows to monitor the both BRIO.



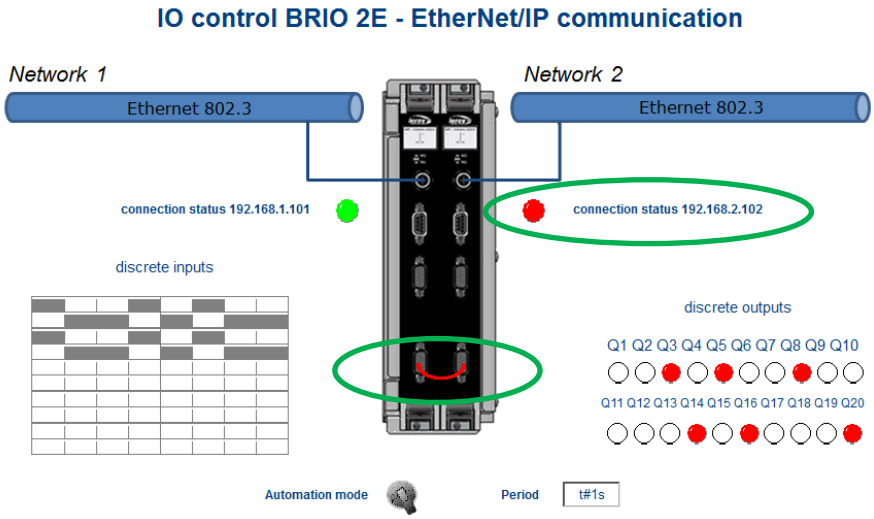
Nominal case:



Network 2 disconnected: management is still complete.



Network 2 disconnected & local link between both BRIO disconnected: management is still OK only on BRIO1.



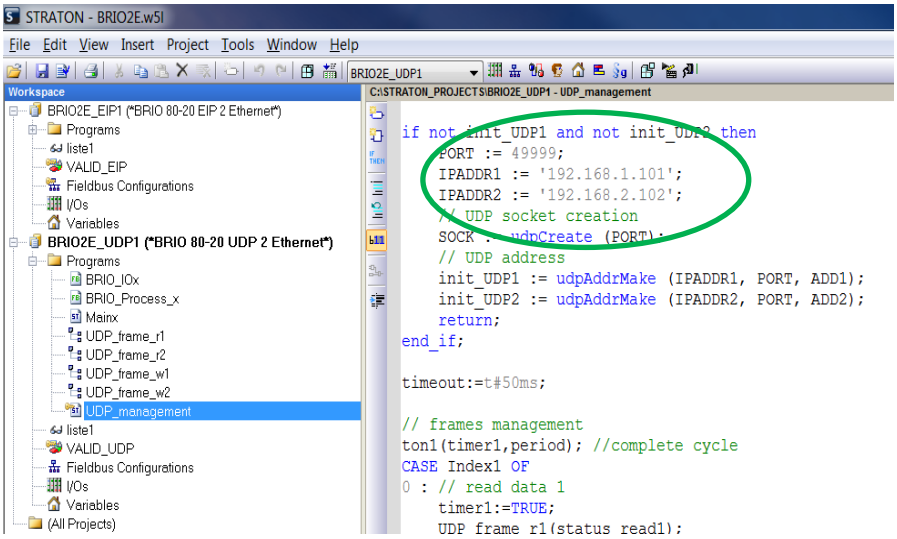
UDP manager

Principle

The project "BRIO2E_UDP1" enables 1 UDP connection with each BRIO:

Configuration

The Communication is programmed with straton functions allowing to manage UDP frames:

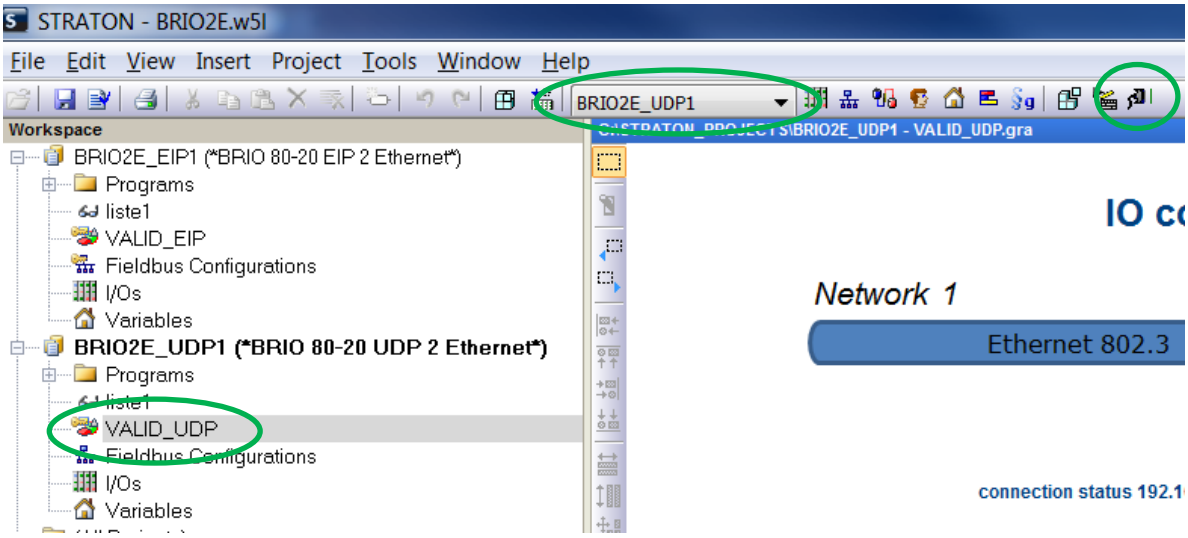


Test

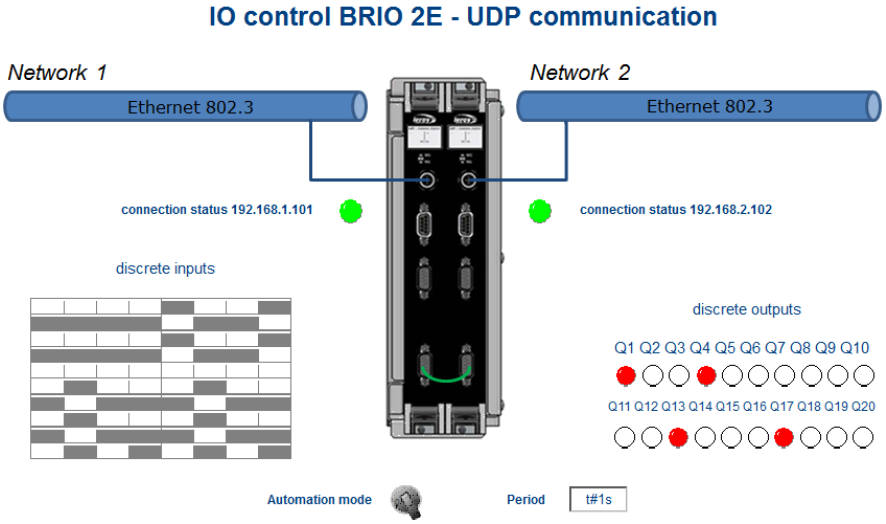
The project BRIO2E_UDP1 shall have been selected, then:

- connect you to the T5 Runtime with the "On line" button
- download the project code into the T5 runtime

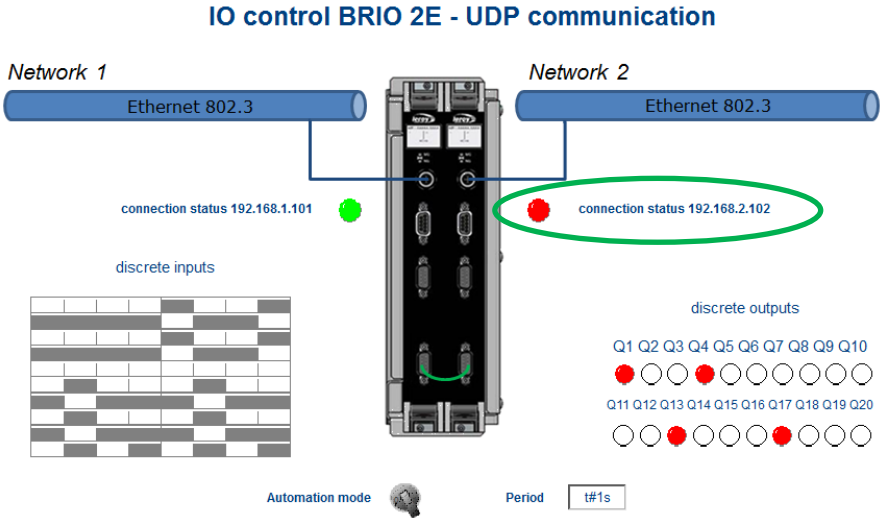
The Graphic window "Valid_UDP" allows to monitor each BRIO.



Nominal case:



Network 2 disconnected: management is still complete.



Network 2 disconnected & local link between both BRIO disconnected: management is still OK only on BRIO1.