Product Description

Duo's Training Box it's a complete and innovative didactic system, presenting features that allow user to simulate elements present in industrial automation, building and machinery systems and is an excellent tool for companies in this sector and Educational Institutions. The Duo's Training Box products are members of the Training Box Series specially developed to provide complete and compact solutions for use in teaching and research laboratories. Mounted on a compact and resistant case, that provides easy transportation and storage.

It consists of a programmable controller (PLC) DU351 Series (PLC with integrated HMI), counts with a central unit that has graphical display 3.2" which allows visualization of programmed elements and the interaction with the process. The PLC has integrated I/O, digital inputs for simulation of field signals and the digital outputs to drive devices. In addition, analog input and output current and voltage are available, and at TB131 model, fast digital outputs of PWM and PTO type for step motor drive and encoder's reading inputs allowing the realization of positioning axes. Finally, it has dedicated circuit to perform control simulations and disturbance in PID loops and has the capacity to link up to 16 PLCs Duo network MODBUS RTU.

MasterTool IEC programming software is free and offers five languages of programming (LD, FBD, ST, IL and SFC), described by IEC 61131-3 and an additional language (CFC). It has simulation feature (programs and HMI screens) that eliminates the use of the PLC for application development and testing, allowing students and technicians to practice and perform simulations even when not using the Duo's Training Box.

The picture on the left shows the Duo's Training Box. Its main features are:

- Terminals for connecting digital inputs with simulation switches and status indication via LEDs
- Terminals for connecting digital relay outputs with status indication via LEDs
- Terminals for connecting analog inputs in scale voltage and current and potentiometers to simulate the inputs
- Terminals to analog output connection
- Digital voltmeter to analog output status indication
- Four terminals to fast input connection
- Step motor for use with fast outputs (only TB131 model)
- Encoder for use with fast counter (TB131 model only)
- Connectors for serial connection of RS-232C and RS-485
- Socket for notebook supply
- Disturbance simulation to PID control study

Ordering Information

Included Items

The product package contains the following items:

- Duo's Training Box TB130 or TB131
- Power supply cable with 1,5 m long
- Programming cable AL-1715
- 8 Cables for connection of the input and output terminals with 0.5 m long

Doc Code: CE122100 Revision: C

Product Code

The following code must be used for product purchase:

Code	Description
TB130	Duo's Training Box Lite
TB131	Duo's Training Box

Related Products

The following products can be purchased separately as needed:

Code	Description
AL-1715	RJ45-CFDB9 Cable
AL-1717	RS-485 Derivador Cable
AL-2600	Derivador and Termination for Network
AL-2301	RS-485 Network Cable (up to 1000 m)
AL-2306	RS-485 Network Cable (up to 500 m)
DU350	PLC with HMI 20DI 16DOT 4AI 2AO
DU351	PLC with HMI 20DI 14DOR 2DOT 4AI 2AO
MT8200	MasterTool IEC
PO8525	Derivador and Termination for RS-485 Network
FBS-USB-232M9	USB-Serial Universal Converter / 2 m

Notes:

AL-1715: This cable has a RJ45 connector and one DB9 female RS-232C standard IBM/PC. It must be used for communication module with the MasterTool IEC programming software and RS-232C point-to-point interface using MODBUS RTU protocol or generic protocol developed by the user.

AL-1717: This RJ45 cable has a serial connector on one side and spring washers for connection to terminals or screw on the other. It can be used for connection between the RS-485 connector TB130/TB131 and PO8525 RJ45 connector, enabling assembly of an RS-485 network.

AL-2301: Shielded cable with two twisted pairs without connectors, to be used in the RS-485 network, as in the case of interconnection of two or more AL-2600, or PO8525 TB130/TB131, with it the maximum length is of 1000 m.

AL-2306: Shielded cable with two twisted pairs without connectors, to be used in the RS-485 network, as in the case of interconnection of two or more AL-2600, or PO8525 TB130/TB131, with it the maximum length is of 500 m. Above 500 m should be used AL-2301 cable.

AL-2600: This module is used for derivation and termination of a RS-485 network. The network can be installed using an AL-2600 for each network node. The communication interface RS-485 TB130/TB131 is connected to an AL-2600. The AL-2600 that is at the endpoint must be configured as termination, if the switch Term. of TB130/TB131 is in OFF position. The rest of the AL-2600 network modules must be set to bypass.

MT8200: The programmer MasterTool IEC (MT8200) is available for free download on the way to the Altus site in www.altus.com.br.

PO8525: This module is used for derivation and termination of a RS-485 network. The network can be installed using a PO8525 for each network node. In PO8525's RJ45 connector is connected the RS-485 communication interface TB130/TB131 using an AL-1717 cable. The PO8525 that are at the endpoint must be configured as termination, if the switch Term. of TB130/TB131 is in the OFF position. The rest of the PO8525 network modules must be set to bypass.

FBS-USB-232M9: This cable is used as an universal interface converter USB to serial interface RS-232C. For use with the Duo's Training Box, simply connect the converter to the DB9 female AL-1715 cable.

Product Features

Specific General Features

	TB130	TB131
Fast Inputs	3 terminals for fast input connection	3 terminals for fast input connection 1 encoder for use with fast counter 1 terminal for configurable fast input connection used in conjunction with the encoder
Fast Outputs	1 terminal for fast output connection 1 common terminal for fast output connection	1 terminal for fast output connection 1 common terminal for fast output connection 1 step motor to be used with fast output

Note:

Fast Inputs: the terminals of fast inputs are shared with the terminals of digital input.

Common General Features

	TB130, TB131
Digital Inputs	9 terminals to digital inputs connection 1 common terminal
Status Indication of the Digital Inputs	8 LEDs to indicate inputs state
Digital Inputs Simulation	8 switches to simulate input values
Digital Outputs	8 terminals to relay digital output connection 1 common terminal
Status Indication of the Digital Outputs	8 LEDs to indicate outputs state
Output Current	125 mA per output or 1 A maximum
Analog Inputs	1 terminal for connection of analog input in voltage scale 1 terminal for connection of analog input in current scale
Analog Inputs Simulation	2 potentiometers for simulation value in the analog inputs
Maximum Current of Analog Input	40 mA
Resistance Series of Analog Inputs	7,3 to 20 Ω
Analog Outputs	1 terminal for connection of analog output
Status Indication of the Analog Outputs	1 digital voltmeter to indicate the value of the analog output voltage
Maximum Current of Analog Output	40 mA
Resistance Series of Analog Outputs	7,3 to 20 Ω
Field connection Interface	1 connector for the RS-485 connection (COM2)
RS-485 Termination	Switch to enable the termination
PID Simulator	1 switch to enable the simulation 1 potentiometer to simulate disturbance
AC Output Supply	Socket to supply Notebook
Maximum AC Output Current	5 A
Power Supply Voltage	90 to 240 Vac
Maximum Input Power	135 VA
Protection Fuse	1 A (only for internal circuit)
Conjunction Power Supply	1 switch to supply 24 Vdc
Operating Temperature	0 to 50 °C
Weight	10 kg
Dimensions	Duo's Training Box closed: 460 x 380 x 165 mm (W x D x H)

	TB130, TB131
	Duo's Training Box opened for operation: 460 x 463 x 475 mm (W x D x H)

Notes:

Features of DU351: The non-presented features in table of features above are the same present by DU351 controller assembled in TB130/TB131. To access those informations see Technical Characteristics of Duo Series (CE113100).

Digital Inputs LEDs: The brightness of the digital inputs LEDs can vary depending on the input voltage placed on the input terminal.

Output Current: The maximum output current is limited by the internal supply of TB130/TB131, this way if a single point is triggered the power supply can handle current up to 1 A for this, but if all points are connected with external loads its only possible to deliver 125 mA per point.

Analog Inputs: Current and maximum series resistance data of analog inputs are due external power supply of the controller DU351 of TB130/TB131. Other data consult CE113100.

Analog Channels Reference: Analog Inputs and Outputs use the same reference signal identified in TB130/TB131 as C4.

Digital Inputs: If the user triggers the digital inputs with an external source and hold the driven simulation switch, the TB130/TB131 will protect against possible short.

AC Output Supply: The socket available to the user is not protected, it means, a short circuit in the mains supply can cause problems in the product.

Dimensions: The dimensions given in the table represent respectively: width x depth x height.

Installation

Electrical Installation

DANGER:

RISK OF ELECTRIC SHOCK

This module can work with voltages up to 240 Vac. Special care must be taken during installation, which should only be done by qualified technicians.

Do not touch the power wiring connection or the socket when in operation.

ATTENTION:

Sensitive device to electrostatic discharge (ESD). Always touch a grounded metal object before handling it.

ATTENTION:

Carefully check the connection of analog signals (AO1, AV2 and AI3). The wrong connection of the respective connectors can cause irreversible damage to the product.

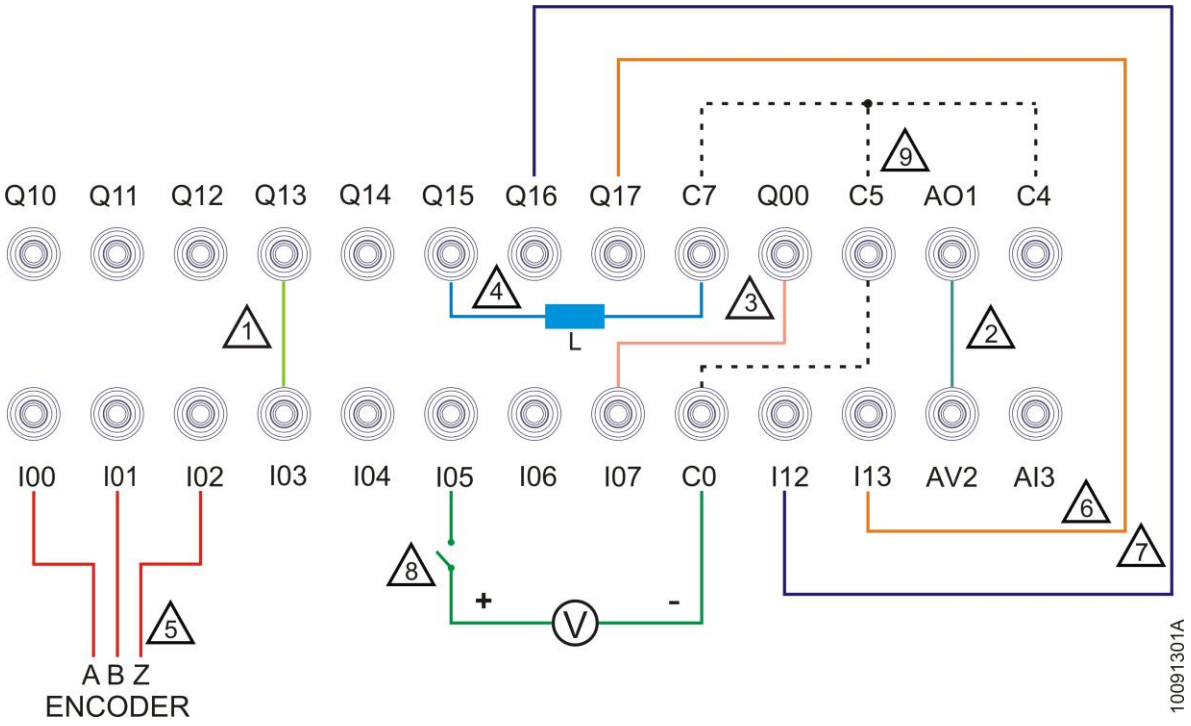


Diagram Notes:

1 – Outputs Q10 to Q17 can be connected directly to inputs I00 to I07 or even in inputs I12 and I13 with no need of common terminal connection.

2 – The output AO1 can be directly connected to AV2 input, the output must be configured as Voltage 0-10V. In the same way the output AO1 can be directly connected to AI3 input, however with the output configured as Current 0-20mA or Current 4-20mA. Only one of the options can be selected and used at once. In both cases there is no need of common terminal connection.

3 – The output Q00 can be directly connected to I00 to I07 or even in I12 and I13 inputs. However when configured as fast output, the connection more convenient is between Q00 and one of the inputs of block 0 of fast inputs (I00, I01 and I02). In both situations, there is no need of common terminal connection.

4 – External loads can be connected to the outputs Q10 to Q17. They may be connected to the output and the common terminal C7. The loads are supplied by the 24 Vdc power supply of TB130/TB131 and all outputs must be connected to the same common terminal C7, paying attention to the maximum current limit f 1 A for all outputs. The output Q00 can be connected in the same way to an external load, however using common C5.

5 – Inputs I00, I01 and I02 are part of fast inputs block 0. They may be configured to operate connected to external pulse generators, for e.g., encoders. In those cases, input I00 must be connected to pin A of encoder, input I01 to pin B of encoder and input I02 to pin Z of encoder.

6 – The input I13 can be directly connected to Q10 to Q17 outputs with no need of common terminal connection.

7 – The input I12 can be directly connected to Q10 to Q17 outputs with no need of common terminal connection. This input is part of fast inputs block 1, its functionality is defined in the configuration. Inputs A and B of this counting block are connected to TB131 encoder and this output can be used, for e.g., to do the resetting of CNT2 counter related to the block.

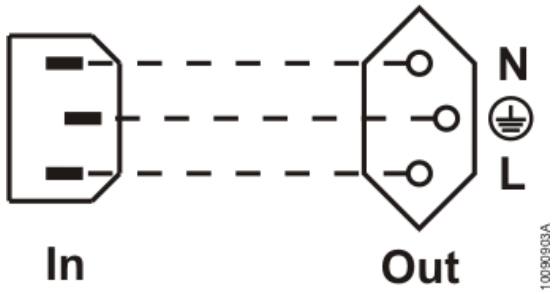
8 – Inputs I00 to I07 or even inputs I12 and I13 can be connected to external sensors. Those sensors must operate between 19 to 30 Vdc and the common of all elements must be connected to the C0 terminal. In these cases the simulation switch of the inputs I00 and I01 of TB130/TB131 must be turned off (OFF) and the brightness of the associated LED may vary depending upon the sensor voltage.

9 – Terminals C0, C4, C5 and C7 as well as ground pins of the input sockets (IN) and outputs (OUT) are internally connected to TB130/TB131.

AC Power Supply

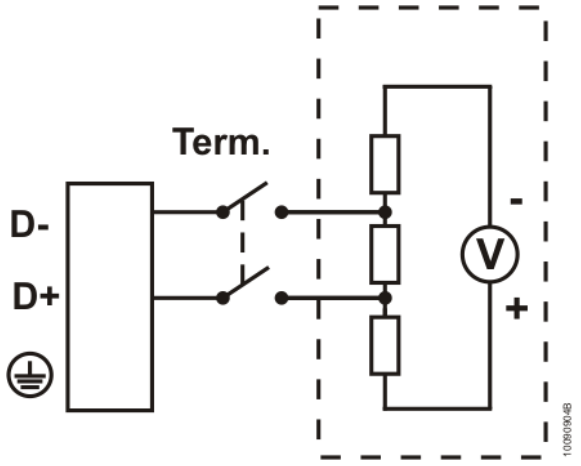
To make easier the use with other devices, such as notebooks or other equipments for didactic use, TB130/TB131 delivers an AC output for Power Supply. This output is identified as OUT and is directly connected to IN, it means, it doesn't pass for any switch or protection device. When the input IN is connected to an AC power supply, the same voltage value will be available in the OUT output, it means, when connected to 127 Vac network supply, there will be 127 Vac available in the output, when connected to 220 Vac network supply, there will be 220 Vac available in the output.

TB130/TB131 switch delivers 24 Vdc that supply the DU351 internal circuits. The diagram below shows the connection between input and the AC output.



RS-485 Termination

TB130/TB131 has termination resistors for connection to RS-485 networks for communication using MODBUS RTU protocol or another protocol implemented using the generic communication functions. When the TB130/TB131 is in one of the endpoint identified as the switch Term, it should be in the on position (ON). If the TB130/TB131 is a node that is not the ends, the switch is in the off position (OFF) .The diagram below shows the connection of terminating resistors and the connector COM2 RS-485 TB130/TB131



Analog Inputs and Output

In addition to connecting the analog output to analog inputs directly, it's possible to also connect external transducers. The diagram below shows some types of connection.

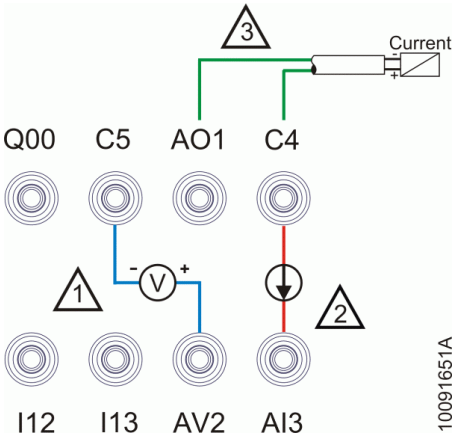


Diagram Notes:

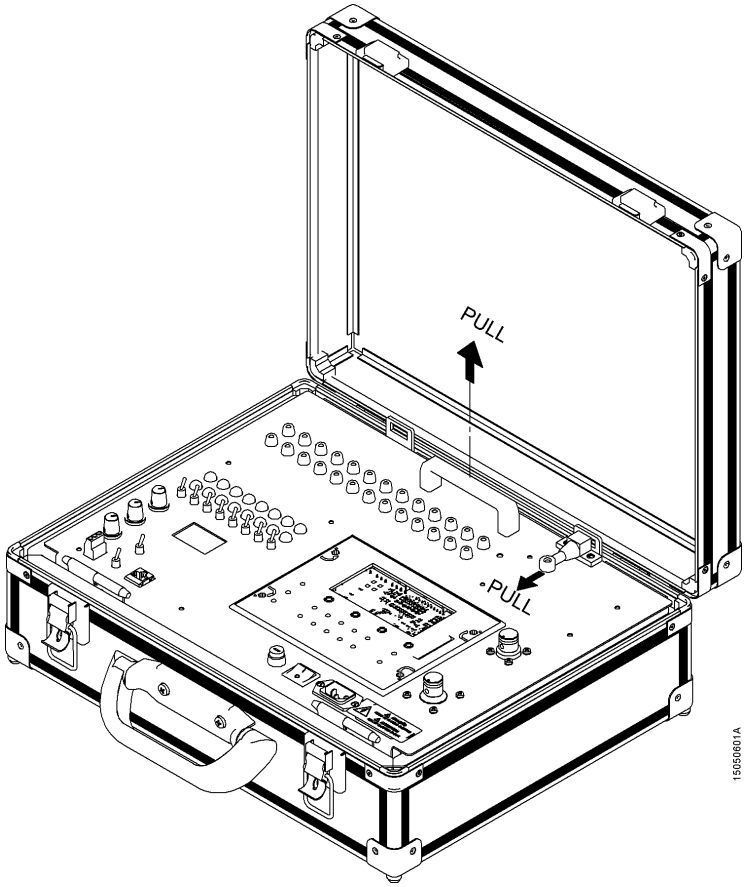
1 – Example of use of the analog input AV2 configured as voltage mode.

2 – Example of use of the analog input AI3 configured as current mode.

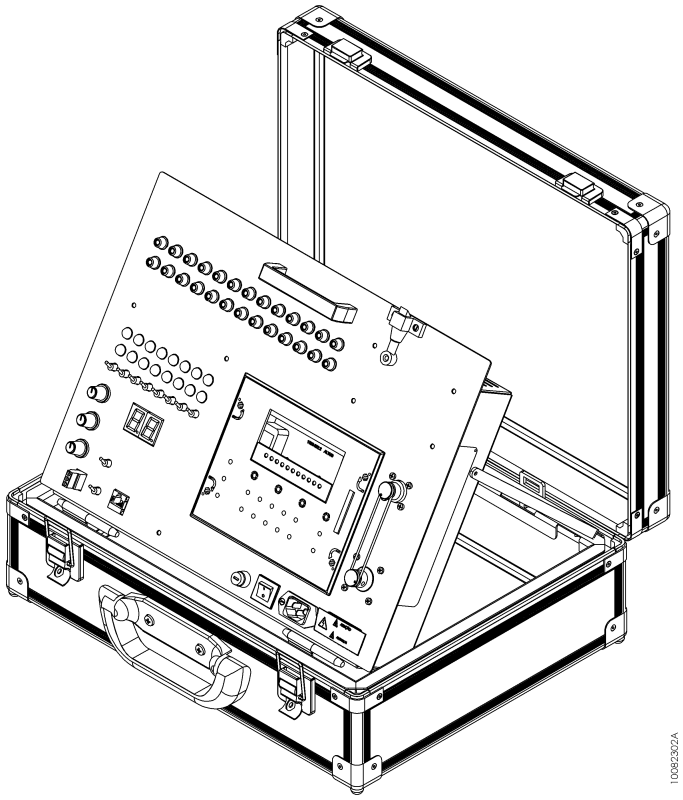
3 – Example of use of the analog output AO1 configured as current mode. The output can also be connected in the same way to a voltage transducer since the output is configured as voltage mode. The connection of a signal 0 to 10V in the current input can cause damage to the product.

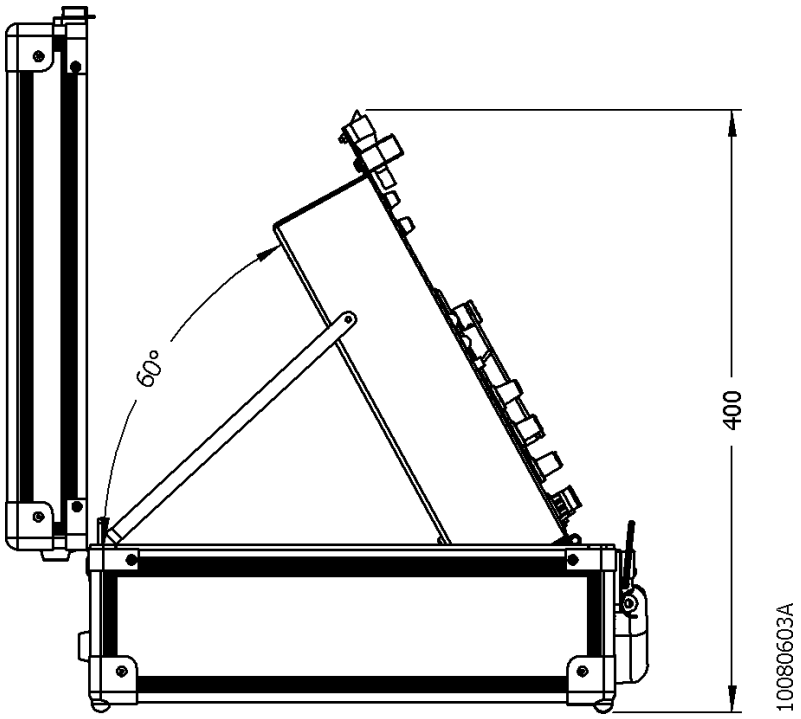
Mechanical Assembly

To use the Duo's Training Box it's necessary to prepare it to use. After open the suitcase the conjunct must be unlocked and raised as follows in the figure below.



After that, place the support strap as shown in the figures below.


100823O2A

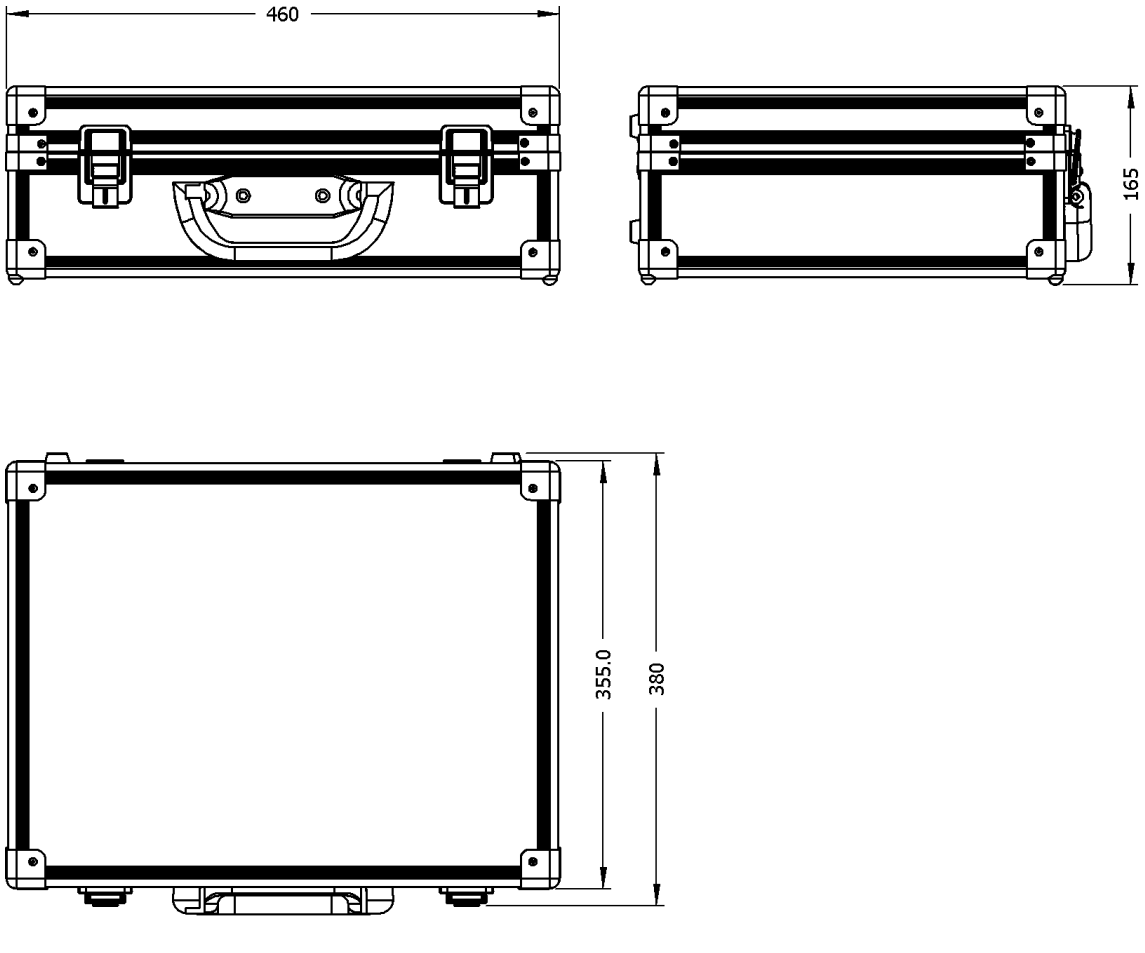


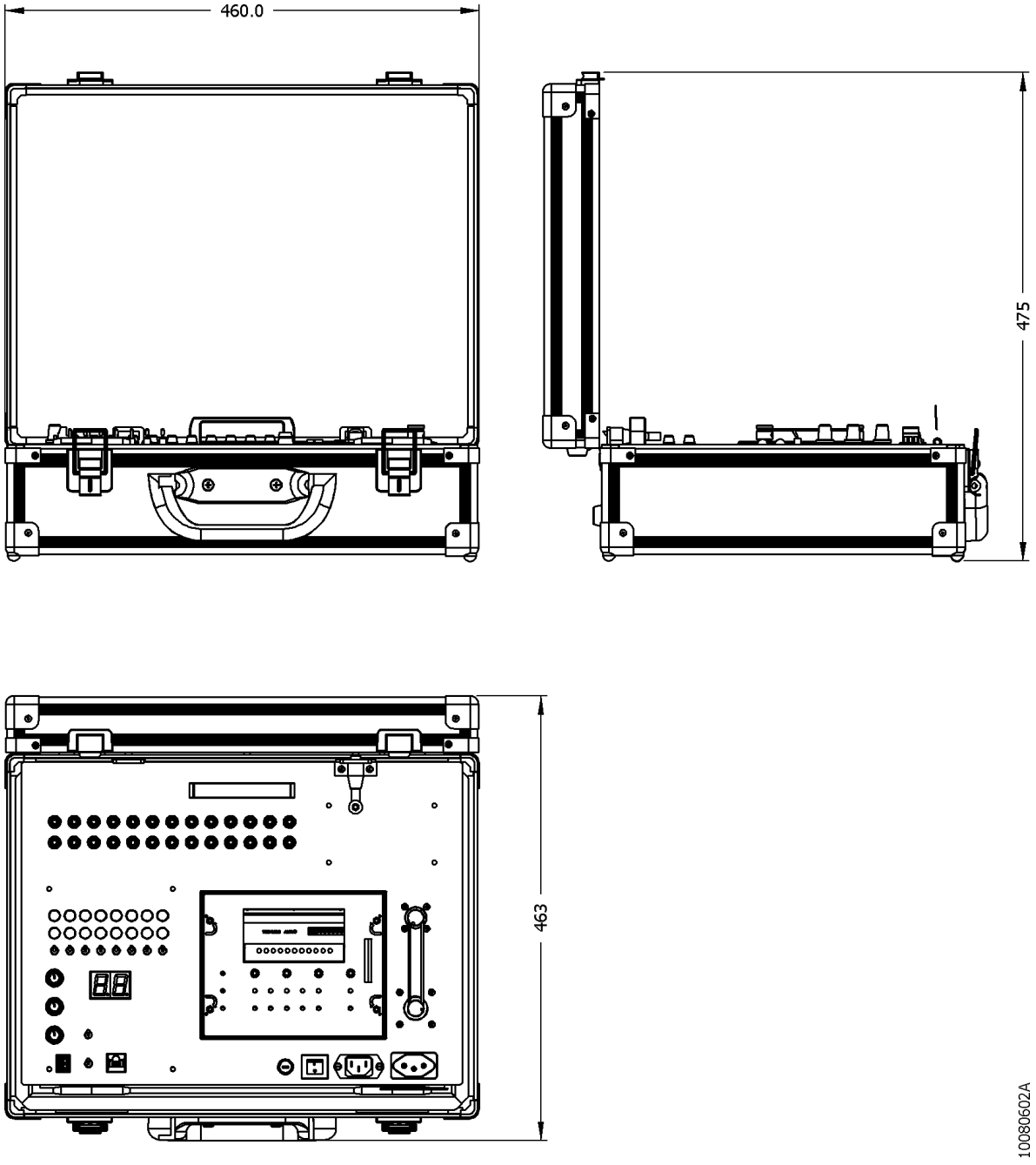
Software Installation

To perform the installation of the programming software MasterTool IEC, it is necessary first to download the installation file on the Altus site www.altus.com.br. For further information about how to perform the software install see the User Manual (MU299606) or DU350/DU351 User Manual (MU213300).

Physical Dimensions

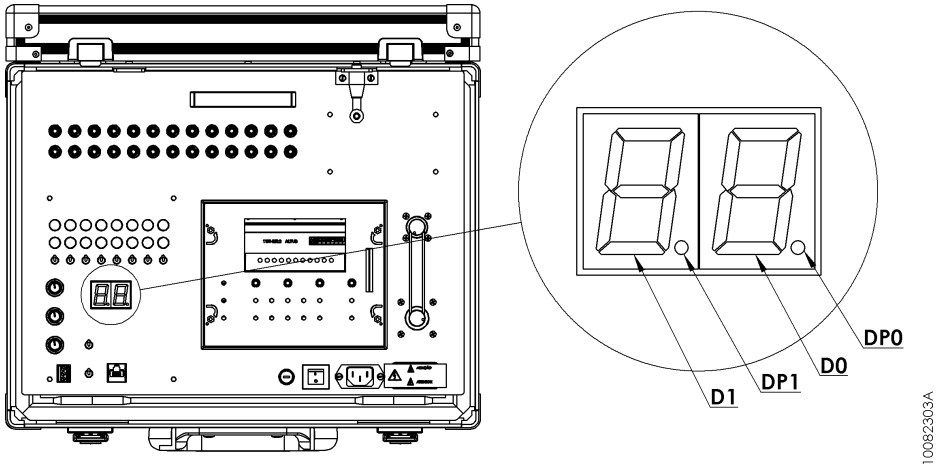
Dimensions in mm.




460.0
475
463
10080602A

Maintenance

The following figure shows the arrangement of characters and points on the digital voltmeter of TB130/TB131.



The table below shows the possible states of the characters and points in digital voltmeter of TB130/TB131 and the meaning for each of these states:

State of Digital Voltmeter				
D1	**DP1**	**D0**	**DP0**	**Meaning**
0 to 9 Blinking	**Blinking**	**0 to 9 Blinking**	**OFF**	This is the state in which the hardware case is starting. It remains in this state for 14 s. While in this state, the suitcase software version is indicated by the digital voltmeter. For example, if D1 = 1 and D0 = 0, then the software version is 1.0.
0 to 9	**ON**	**0 to 9**	**OFF**	Indicates the analog output value of AO0 from 0.0 to 9.9 in V. For example, if D1 =5 and D0 = 7, then the AO0 value is 5.7 V.
1	**OFF**	**0**	**ON**	Indicates the value of the analog output AO0 equal or bigger than 10 V.
F	**OFF**	**1**	**OFF**	A Timeout occurred in the analog digital conversion of the AO0 reading value.
F	**OFF**	**2**	**OFF**	Failure in the conversion tables of the step motor or in the digit conversion of the digital voltmeter.
F	**OFF**	**3**	**OFF**	Software Watchdog occurred in TB130/TB131.

DU351 diagnostics operands are available in the table of operands in DU350/DU351 User's Manual (MU213300).

Programming

DU351 controller present in Duo's Training Box uses languages described in IEC 61131-3 standard, those are IL, ST, LD, SFC and FBD. These languages can be shattered in graphical and textual. IL and ST, textual languages, are similar to assembly and C, respectively. LD, SFC and FBD are graphical language, where LD uses relay and blocks representation, facilitating by being similar to the relay diagrams; SFC uses the representation of a sequence diagram, making it easy to visualize the sequence of events and FBD uses an array of function block, allowing to see clearly the functions performed in each action.

The programming is made by MasterTool IEC developing software that allows the use of the five languages in the same project, also allowing to the best use of features of each language, resulting in the development of a robust applicative and of easy understanding and maintenance.

For further informations about programming see the User's Manual (MU299606), the standard IEC 61131-3 or DU350/ DU351 User's Manual (MU213300).

To see examples of applications using the DU351 and TB130/TB131 access the tutorials available in the downloads section of the Altus site www.altus.com.br.

Configuration

Duo's Training Box offers to the user access to resources of the PLC as described as follows.

Digital Inputs

Access to 8 digital inputs of group 0 is allowed. The digital inputs are 24 Vdc and made available through the yellow terminal, located on the top panel. Driven through the simulation switch or external signal connected to terminals. Each input has a LED indicating the input state. The terminals, LEDs and simulation switches of the entries are identified I00 to I07. These are the same identifiers used inside the DU351 controller and can also be accessed directly by address% IX0.0 the IX0.7% respectively.

It's also allowed access to 2 inputs of group 1As well as inputs from Group 0, Group 1 of inputs is 24 Vdc and made available through yellow terminals. They are identified as I12 and I13 and do not have LEDs and switches for simulation. The identifiers are the same used in the DU351 controller and can also be accessed directly by address IX1.2% and IX1.3%, respectively.

Digital Outputs

It provides to the user access to 8 digital outputs of group 1. The digital outputs are 24 Vdc available via red terminals, located on the top panel. Each output has an LED indicating their state; moreover, the signal can be directly accessed at its respective terminal. The terminals and the LEDs of the outputs are identified Q10 to Q17. These are the same identifiers used inside the DU351 controller and can also be accessed directly by address% QX1.0 to QX1.7%.

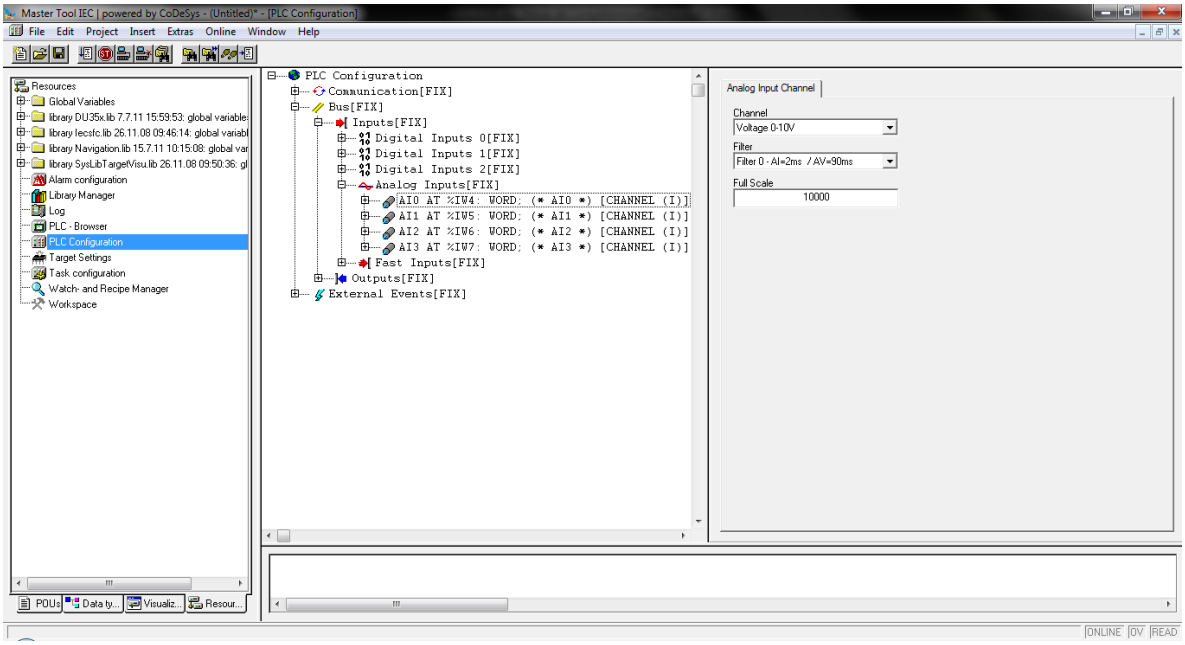
Analog Inputs

The analog inputs 0 and 1 are connected to the potentiometers identified as AV0 and AV1, simulating the field sensor behavior. The value of those inputs can be accessed by the identifiers AI0 and AI1 in DU351 controller or directly by the address %IW4 and %IW5. To use the potentiometers its necessary to configure those inputs as *Voltage 0-10V* in *Channel*.

The analog input 2 is available by the AV2 terminal and allows Voltage signal reading of 0-10 V. The value of this input can be accessed by identifier AI2 in DU351 controller or directly in %IW6 address. To use this input its necessary to configure it as *Voltage 0-10V* in *Channel* If this input is configured differently it cannot be used in TB130/TB131.

The analog input 3 is available by the AI3 terminal and allows Current signal reading in 0-20 mA or 4-20 mA. The value of this input can be accessed by identifier AI3 in DU351 controller or directly in %IW7 address. To use this input it's necessary to configure it as *Current 0-20mA* or *Current 4-20mA* in *Channel*. If this input is configured differently it cannot be used in TB130/TB131

The configuration of the analog inputs is performed in the MasterTool IEC software under the Resources tab, as the image below shows:

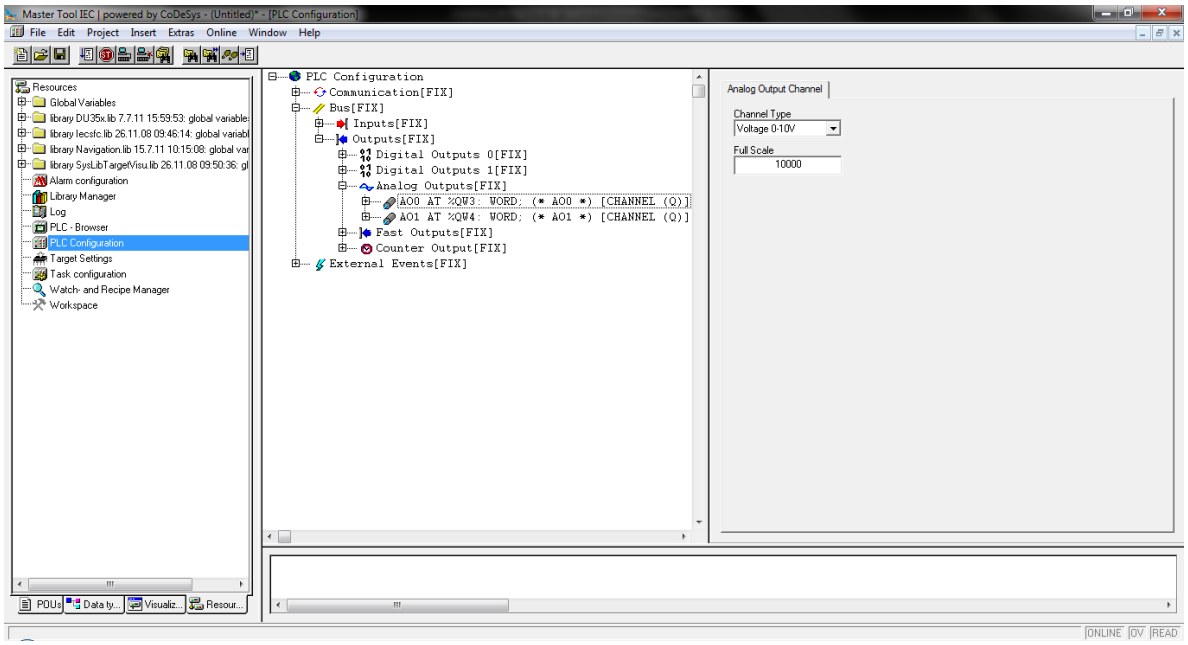


Analog Outputs

The analog output 0 is connected to the digital voltmeter identified as AO0. The value of this output can be accessed by identifier AO0 in DU351 controller or directly in %QW3 address. To use the digital voltmeter it's necessary to configure it as *Voltage 0-10V* in *Channel*. If this output is configured differently it cannot be used in TB130/TB131. Case this occurs the behavior of the digital voltmeter will not correspond to the values of the analog output variable AO0.

The analog output 1 is available by the AO1 terminal. The value of this output can be accessed by identifier AO1 in DU351 controller or directly in %QW4 address. To use this output it's necessary to configure it as *Voltage 0-10V or Current 0-20mA* in *Channel.* The behavior of the output depends of the way it is configured as.

The configuration of the analog outputs is performed in the MasterTool IEC software under the Resources tab, as the image below shows.

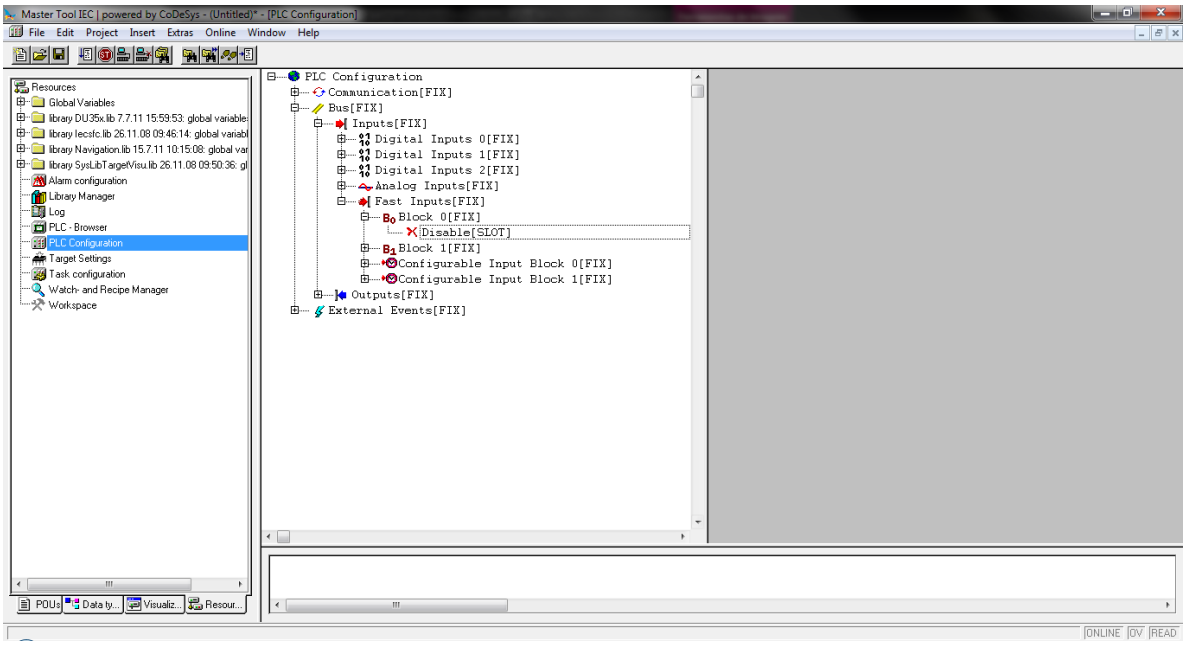


Fast Inputs (TB131)

The fast inputs are shared with the common inputs; they're the first 3 of each block (Block 0 and Block 1). Fast inputs can be configured as unidirectional counters (2) or bidirectional counters (1). In TB131 are located the fast inputs on Block 0 and are available by the terminals of digital inputs I00 to I02, they also can be configured to 2 unidirectional counters or 1 bidirectional counter. Counting values are available directly in CNT0 (%MD1619) variables that receives the value of the counting from channel 0 (I00) and CNT1 (%MD1626) that receives the counting value of channel 1 (I01). When the Block 0 is configured as Bidirectional counter only CNT0 is used.

The fast inputs of Block 1 are internally connected to the encoder of the Duo's Training Box and must be configured in *Counting Mode* as *Bidirectional Counter* in *Quadrature 2x* or *Quadrature 4x*. Counting values are available directly in CNT2 (%MD1633) variable. If *Quadrature 2x* is configured, the counter increments 400 times at each complete cycle of the encoder. If *Quadrature 4x* is configured, the counter increments 800 times at each complete cycle of the encoder. As the encoder of TB131 has not resetting input, the counter can CNT2 can be reset through configurable input block 1 available in I12 terminal.

The configuration of the fast outputs is performed in the MasterTool IEC software under the Resources tab, as the image below shows:



Fast Outputs (TB131)

The fast output 0 is available for access through terminal Q00. It can be configured to operate as a PTO, VFO / PWM output or together with the fast inputs of the block 0. The main settings necessary for the operation of this output are available on the following variables:

- F0_FREQ (%MD1647): Frequency of the output signal
- F0_DUTY (%MB6600): Signal time percentage in logic level “1” (Only used for VFO/PWM)
- F0_PLS_TOT (%MD1648): Total amount of pulses (Used only for PTO)
- F0_PLS_RMP (%MD1649): Amount of pulses per acceleration ramp / deceleration (Used only for PTO)
- F0_PTO_START (%MX3314.0): Enables the pulse trigger of fast output

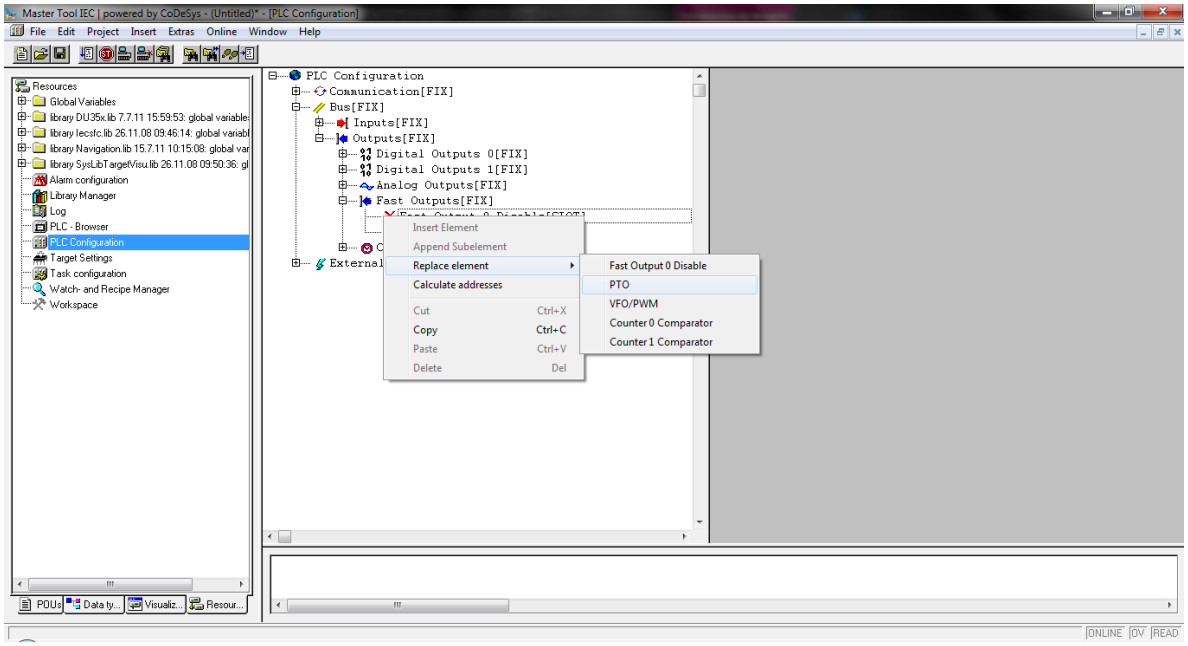
Fast output 1 is internally connected to control the step motor. The fast output 1 should be set to PTO, and if not used in this manner may result in undesired behavior at the output, and prevent the control the number of pulses on the output. The main settings for the operation of this output are available in the following variables:

- F1_FREQ (%MD1652): Frequency of the output signal
- F1_PLS_TOT (%MD1653): Total amount of pulses
- F1_PLS_RMP (%MD1654): Amount of pulses per acceleration ramp / deceleration
- F1_PTO_START (%MX3314.2): Enables the pulse trigger of fast output

To control the step motor, moreover the fast output, also are used another DU351 outputs, as described below:

- Q02% or QX0.2: digital output responsible for the direction of step motor rotation. If it is in logic state "0" indicates clockwise, and if in logic state "1" anti-clockwise.
- Q03 or %QX0.3: digital output responsible for enable the step motor. If it is in logic state “1”, the motor coils remain energized even when there is no movement and if it is in logical state “0”, the motor coils will be energized only while the movement, standing the free axis.
- Q04 or %QX0.4: digital output responsible per select the amount of steps for cycle. If it is in logic state “0”, will be necessary 200 fast output pulses to execute a full cycle and if it is in logical state “1”, 400 fast output pulses will be necessary to complete a cycle.

The configuration of the fast outputs is performed in the MasterTool IEC software under the Resources tab, as the image below shows:

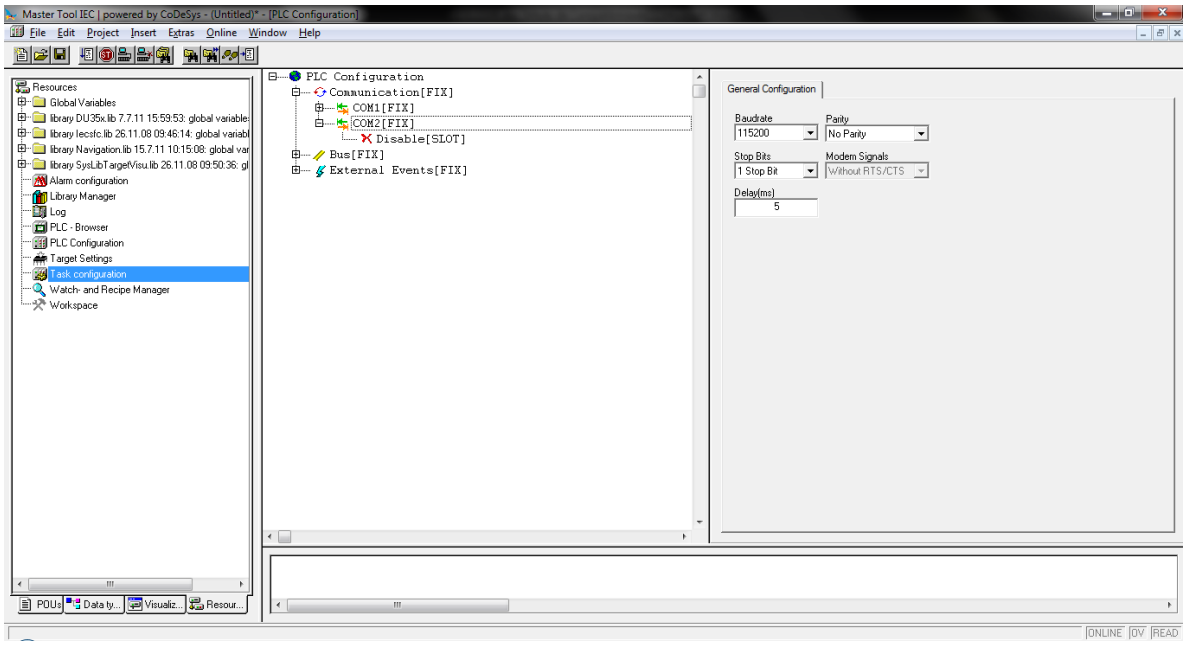


Communication Ports

Two communication ports of DU351 are available to the user:

- RS-232C: interface for programming Duo via MasterTool IEC or MODBUS Master and Slave protocol communication or generic protocol developed by the user. When the COM 1 port is configured for MODBUS communication, this becomes the current protocol on this port. To perform new programming you must configure the port to communicate with the MasterTool IEC protocol. If the protocol selected in the configuration is not this, the protocol must be changed using the keys MAIN + arrow down of DU351.
- RS-485: interface for communication in network between devices. Owns the MODBUS Master / Slave Protocol and a generic protocol developed by the user. It's not possible to configure Duo using this communication interface. RS-485 TB130/TB131 connector allows the right access signals of differential pair and also to the ground. This interface also allows a network termination to be configured. Always that TB130/TB131 is the first or last node of a network, the termination identified as Term. needs to be in ON. If not, this switch must be in the position OFF.

The configuration of the communication ports is performed in the MasterTool IEC software under the Resources tab, as the image below shows:



PID Simulator

The Duo's Training Box provides to the user a process simulator. It is an electronic circuit coupled to internally TB130/TB131. This feature is enabled by switch located next to the PID identifier.

The Duo plays the PID controller and interacts in the following ways:

- The circuit receives at its input a signal 0-10V that is generated by the analog output AO1 or %QW4 of Duo and simulates VM (Variable Measure).
- The output of the electronic circuit is a response to the input signal. The circuit simulates a process of the second order that can be approximated to a linear first order process with dead time. After passing through the circuit, the signal is sent to the analog input AI2 or %IW6 of Duo, simulating the PV (Process Variable).
- The PID circuit simulator has a potentiometer that adds a disturbance to the signal with amplitude up to 1V. Thus allows to disturb the circuit output (PV).

Manuals

For further technical details, configuration, installation and programming of products Duo series, the following documents should be consulted:

Document Code	Description
CE113100	Technical Characteristics of Duo Series
MU213300	User Manual of DU350 / DU351
MU299606	Manual de Utilização MasterTool IEC
MU299608	Manual de Utilização da Visualização do MasterTool IEC