OPD EXP
SYSTEM

BDF DIGITAL

E|C|S

TDE MACNO

SUMMARY

1   INTRODUCTION

This guide assists users in the commissioning of OPDE drive. This document must be used only by BDF DIGITAL personnel, or by authorized users.

This guide explains how to do the first commissioning of a drive, this means that in the drive, parameters have not yet been set for the application.

Follow the instructions in this guide carefully to avoid damage, failure or malfunction.

2   COMMISSIONING STEPS

OPDE drive's commissioning procedure can be summarized as follows:

- o Motor parameters loading;
- o Sensor parameters loading;
- o Connection and Autotuning testing;
- o Speed control calibration;
- o Core and Application Updating.

OPDE's commissioning procedure can be execute on board, by drive's keypad, or by supervisor OPDExplorer installed on a PC, available on BDF DIGITAL website. The last mode is the most comfortable and suggest one. Indeed, this guide is focus on the OPDExplorer approach.

2.1   MOTOR PARAMETERS LOADING

First is necessary enstablish a connection between the drive and the supervisor following this steps:

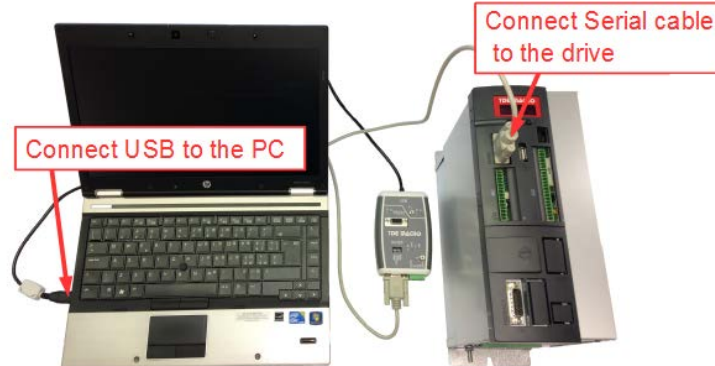- o Connect the drive to the OPDExplorer by the USB RS485-232 converter;

Fig. 1-PC-Drive connection

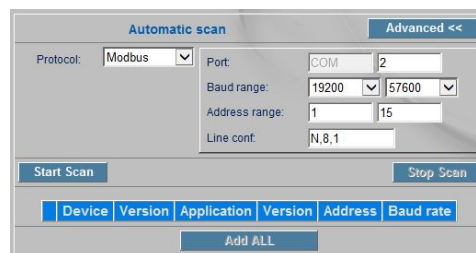- o Start **Scan** function to find the drive cabled to the serial line;

Fig. 2-Scan

- • If it's necessary set the right Modbus communication parameters,

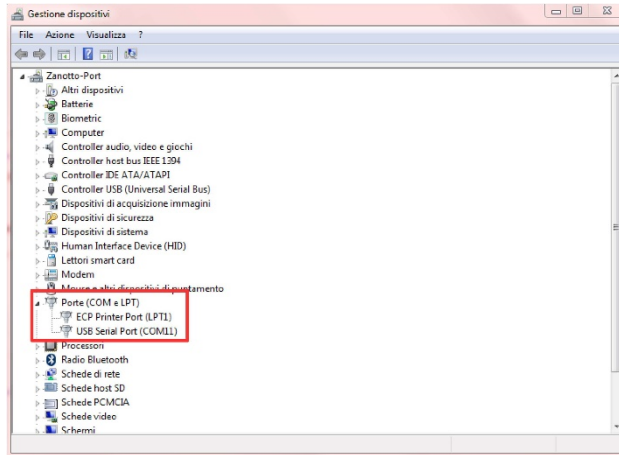clicking **Advanced >>** (usually COM port setting is enough).

Fig. 3-COM port

- Click **Start Scan** ; at the end of scan is going to be showed the drive found.
- Click **Add** ; in this way OPDExplorer open a project coherent with the drive; next push

 .

Essential motor parameters (nameplate data) are contained in the following directory

All Parameters > Asynchronous Parameters > Drive and Motor Coupling > Motor Plate
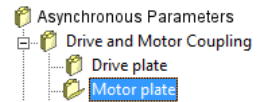
Nome	Descrizione
PRC_MOT_I_NOM	P61 – Rated motor current (I NOM MOT)
MOT_V_NOM	P62 – Rated motor voltage
MOT_F_NOM	P63 – Rated motor frequency
MOT_SPD_MAX	P65 – Max operating speed
MOT_POLE_NUM	P67 – Number of motor poles

All Parameters > Brushless Parameters > Drive and Motor Coupling > Motor Plate
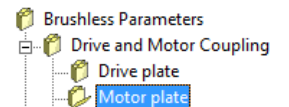
Nome	Descrizione
PRC_MOT_I_NOM	P61 – Rated motor current (I NOM MOT)
MOT_V_NOM	P62 – Rated motor voltage
MOT_SPD_NOM	P63 – Rated motor speed
MOT_SPD_MAX	P65 – Max operating speed
MOT_POLE_NUM	P67 – Number of motor poles

These parameters are fundamental in that they are the basis of all the motor operating characteristics: frequency, speed, voltage, current, torque and thermal protection. P62, P63, P65 and P67 can be read directly on the motor rating plate instead P61 can be calculated with the following formula:

$$P61 = \frac{Inom\_motor}{Inom\_drive} \cdot 100.0$$

In Brushless motor, the voltage value can be specified in V or as BEMF value (V/krpm).

In order to load motor parameters click **Unlock Reserved Parameters** (equal to parameter P60) and write **95**.

Write motor data to the relative parameters and confirm clicking **Write Parameters** (values change from red to black).

Save the data just loaded into RAM to EEPROM by clicking **Save Parameters to EEPROM** (equal to set **C63=1**). During saving drive's display will show "**BUSY**".

For more info view **OPDE User Manual**.
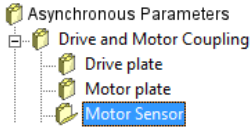
2.2 SENSOR PARAMETERS LOADING

Essential sensor parameters are contained in the following directory

All Parameters > Asynch. / Brushless Parameters > Drive and Motor Coupling > Motor Sensor

In order to load sensor parameters click **Unlock Reserved Parameters** (equal to parameter P60) and write **95**.

Please refer to **OPDE User Manual** to set the correct parameters in the **Motor Sensor** directory.

Save the data just loaded into RAM to EEPROM by pressing **Save Parameters to EEPROM** (equal to set **C63=1**). During saving drive's display will show "**BUSY**".
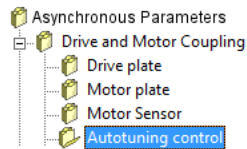
2.3 CONNECTIONS AND AUTOTUNING TESTING

Connections test execute a compensation of the sensor offset and gain signals and it's divided into three parts:

o Check that the direction of rotation of the motor phases and the sensor correspond;
o Automatic offset and gain sensor signals compensation;
o Check that the number of motor poles is written correctly in parameter P67 and the speed sensor used is set correctly.

Autotuning test reads the basic electrical parameters that characterise the induction motor being used, so it can be modelled according to the rotor magnetic flux. After these values have been established, the PI regulators in the current and flux loops are self-set.

There are 4 autotuning test functions. Each requires a no-load motor, i.e. decoupled from the load, if they are to function correctly.

These tests needs the P60 key. Click **Unlock Reserved Parameters** (equal to parameter P60) and write **95**.

Set the parameter **PRC_I_TEST_CONN (P114) = P61**.

To view the status of the test you can use the **Display** of OPDExplorer and press the **Show Drive Display** button, or else you can use the keypad of the drive.

Asynchronous Parameters
Drive and Motor Coupling
Drive plate
Motor plate
Motor Sensor
Autotuning control

2.3.1 CONNECTIONS TEST AND SENSOR CALIBRATION – C41

Using the connection **EN_TEST_CONN (C41) = 1-Yes** it's possible to automatically execute the test connections and also the calibration of the sensor.

If an asynchronous motor is being used with V/f **EN_VF_CNTL (C80) = Yes**, C41 test don't have to be done.
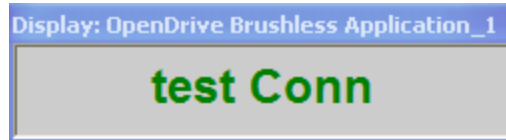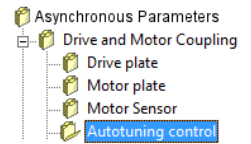

Fig. 4-The connection test is enabled

After C41 tests enabling, give run command to the drive. The drive will initiate the test procedure if all enables are present, namely: **Hardware enable I00=1** (default is logic input L.I.4) and **Software enable C21=1**.

The test will be initiated if no alarm is present on the drive.

Some applications inhibit the "enable from fieldbus" function, as it is reserved for the application itself (the drive will not run!!!). In this case, follow the procedure described below (after setting C41=0/No):
- Set the **SW_RUN_CMD** (**C21**) connection to **No**
- Set the **EN_START_UP_APPL** (**U05**) connection to **Yes**
- Set the **EN_TEST_CONN** (**C41**) connection to **Yes**
- Set the **SW_RUN_CMD** (**C21**) connection to **Yes**

These connections are located in the following directory:

All Parameters > Brushless Parameters > Drive and Motor Coupling > Quick Start-up

If all enables are set correctly, the motor will start running the connection test.

Fig. 5-The connection test is being executed

If C.End appears in the **Display** window, it means that the test was successful.

Fig. 6-End of connection test while drive is running

2.3.2 AUTOTUNING TEST – C42

The test-tuning differs depending on whether you are working with a brushless motor or an induction motor.

In the case of the brushless motor, the Autotuning expects to perform only the test corresponding to **C42=1**. So it will be necessary to set the parameter **EN_AUTOTUNING** (**C42**) on **1-Standard Test**.

In the case of the induction motor, the Autotuning expects to perform two types of tests: **C42=1**, **C42=2**. It will then run the first test by setting the parameter **EN_AUTOTUNING** (**C42**) on **1-Test 1 and 2** and the second test by setting the parameter **EN_AUTOTUNING** (**C42**) on **2-Test 3 and 4**.
You can also perform both tests in sequence by setting the parameter **EN_AUTOTUNING** (**C42**) on **3-All**.

Once having set on C42 the test to run, to execute the test it's necessary to command the drive run. The drive will initiate the test procedure if all enables are present, namely: **Hardware enable I00=1** (default is logic input L.I.4) and **Software enable C21=1**.

To view the status of the test you can use the **Display of** OPDExplorer and press the **Show Drive Display** button, or else you can use the keypad of the drive.

The test will be initiated if no alarm is present on the drive

Fig. 7-Autotuning is enabled

Some applications inhibit the "enable from fieldbus" function, as it is reserved for the application itself (the drive will not run!!!). In this case, follow the procedure described below (after setting C42=0/No):
- Set the **SW_RUN_CMD** (**C21**) connection to **No**
- Set the **EN_START_UP_APPL** (**U05**) connection to **Yes**
- Set the **EN_TEST_CONN** (**C41**) connection to **Yes**
- Set the **SW_RUN_CMD** (**C21**) connection to **Yes**

These connections are located in the following directory:

All Parameters > Brushless Parameters > Drive and Motor Coupling > Quick Start-up

If all enables are set correctly, the motor will start the autotuning test.

Fig. 8-Autotuning is being executed

If **A.End** appears in the **Display** window it means that the test was successful.

Fig. 9-End of Autotuning while drive is running

At the end of the test remove the run command and the drive will return in "**Stop**" status.

The application works only if the **EN_START_UP_APPL** connection is set back to **No**, so:

- Set the **SW_RUN_CMD** (**C21**) connection to **No**
- Set the **EN_START_UP_APPL** (**U05**) connection to **No**
- Set the **SW_RUN_CMD** (**C21**) connection to **Yes**

Save the test data to EEPROM by pressing **Save Parameters to EEPROM** 🖳 (equal to set **C63=1**). During saving drive's display will show "**BUSY**".

Optional: The parameters that are obtained by running Autotuning starting from the default values might not always be optimal. For this reason, we recommend that you repeat Autotuning, starting from the values obtained in the previous estimate.
Thus, execute Autotuning a first time with the **DIS_DEF_START_AUTO** (**C95**) connection set to **No**, and then a second time with the **DIS_DEF_START_AUTO** (**C95**) connection set to **Yes.**

2.4   SPEED CONTROL CALIBRATION

Speed control calibration is necessary if you wish to obtain the best possible performance out of the system, it can be done automatically or manually.
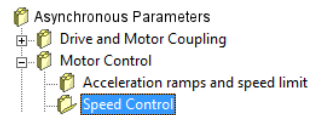
2.4.1   AUTOMATIC CALIBRATION

The automatic calibration of the speed control is a procedure that allows to automatically calculate the gains and time constants of the filters of the speed regulator necessary to have a speed loop characterized by a bandwidth equal to that set by the user via parameter, while maintaining a phase margin to ensure adequate stability.
This means that the speed step response will be the faster the higher the bandwidth of the system, while the overshoot of speed will always be the same.

Before performing the automatic calibration of the speed loop, is necessary to characterize the system by performing the measurement of the **starting time** which is defined as the time that the "**motor + load**" takes to reach the maximum speed by applying the rated torque.
First of all you need to set, on the parameter **TEST_SPD_T_MAX** (**P130**), the maximum torque that you want to deliver during the test. With the parameter **TEST_SPD_MAX** (**P132**) you can set the maximum test speed and with the parameter **TEST_SPD_SPACE_MAX** (**P134**) you can also set the maximum number of motor revolution admitted during the test. With these parameters you can set the test so that it can be performed even in situations where the motor has some movement limitations due to the application in which it is inserted.

To enable the test it's necessary to set the parameter **EN_TEST_SPD** (**U01**) on **1-Start Up**, the display will show "**test Auto**", then give the run command. The motor will perform a rapid acceleration followed by rapid deceleration. After the test, remove the run command and save the parameters on EEPPROM. In the parameter **START_TIME** (**P169**) will be returned the start-up time measured. The measure is the more accurate the higher the motor speed and torque applied to the motor during the test.

At this point you can proceed with the automatic calibration of the speed loop by selecting on parameter **SPD_REG_SETTING** (**U02**), one of four modes available:

- 1 – Stable;
- 2 – Medium;
- 3 – Dynamic;
- 4 – Max;
- 5 – Manual.

The first four modes allow you to choose a response of the speed loop having a gradually increasing bandwidth, the **Manual** mode allows you to choose a bandwidth specified manually by the user through the parameter **SPD_LOOP_BW** (**P20**).
The bands that are obtained in this different cases are as follows:

U02 = 1–Stable	→	BW_{vel}=2,5 Hz	P31<50
U02 = 2–Medium	→	BW_{vel}=15 Hz	P31<50
U02 = 3–Dynamic	→	BW_{vel}=20 Hz	P31<50
U02 = 4–Max	→	BW_{vel}=BW @ P31=50	BW_{vel} <BW_{corr}/4
U02 = 5–Manual	→	BW_{vel}=P20	P31<100

where BW_{vel}=speed-loop bandwidth
           BW_{corr}=current-loop bandwidth

Once written the U02 parameter, it will be automatically calculated parameters **P31**, **P32**, **P33**, **P34**, and will appear on parameter **SPD_LOOP_BW** (**P20**) the bandwidth obtained. After being set, U02 will automatically reset at 0 value. To see the new values of P31, P32, P33, P34 **Refresh** the page.

If you want to manually set the bandwidth, you have first to write the desired bandwidth in parameter **SPD_LOOPBW** (**P20**) and then set parameter **SPD_REG_SETTING** (**U02**) on **4-Manual**.

To verify the calibration of the speed, is a good idea to make a step response by controlling the response by <u>Real-Time Graph</u>. Before performing the test, you must set the parameters **TEST_SPD_MAX** (**P132**) and **TEST_SPD_SPACE_MAX** (**P134**) that let you select the maximum speed and maximum revolutions to be performed during the step response.
At this point, set the **Real-time Graph** to show the trace **Reference speed value after ramp (o03)** and **Rotation speed (o04)** and ser the trigger on **o03-Reference speed value after ramp**.

Set the "**Post trigger points**" to 90% and the "**sample time**" to 0.5 ms.
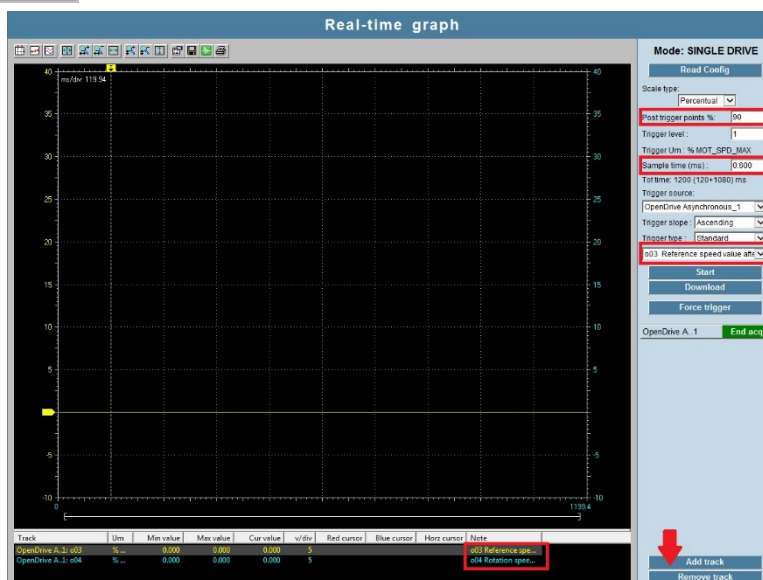Click   [Start]   to start a new acquisition.

Fig. 10-Step response configuration

Then, to enable the test is sufficient to set **EN_TEST_SPD** (**U01**) on **2-Step**. The display will show "**test Auto**" at this point you can give the run command, wait for the execution of the step response (in Real-Time Graph "**Monitoring**" become "**End acq**"), and then remove the run command (if you have used the TEST_SPD_SPACE_MAX (P134) parameter, the motor will stop automatically to the achievement of set value). The reference speed is limited by the parameters written in TEST_SPD_T_MAX (P130) and TEST_SPD_MAX (P132).

For example, if TEST_SPD_T_MAX (P130) = 100.0% (no limitation), TEST_SPD_MAX (P132) = 50.00% and TEST_SPD_SPACE_MAX (P134) = 20.00, the speed reference will be 1500 rpm for 20 revolution (if MOT_SPD_MAX (P65) = 3000 rpm).

Then check the speed loop response on <u>Real-Time Graph</u>.

Click [Download] to download the track.

Fig. 11-Step response example

Pay attention to the fact that the U01 parameter does not automatically return to **0-Not Enabled** at the end of the step response, this should be done by the user.

2.4.2 MANUAL CALIBRATION

In order to calibrate the speed control gains, you will need to use the STEP function. To enable the STEP function, set the **EN_TEST_SPD** (**U01**) connection to **2 – Step** (with the drive on STOP).
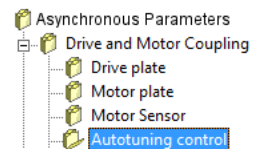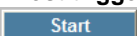

Before starting the calibration procedure, set the speed gains as follows:

- P31 - KpV final speed regulator proportional gain = 4.0 (default)
- P32 - TiV final speed regulator lead time constant > 500 (reduces/excludes the integral part)
- P33 - TfV final speed regulator (filter) time constant = 0.8 (default)

Use the Real-time Graph configuration of fig.10: set the **Reference speed value after ramps (o03)** and **Rotation speed (o04)** tracks on the Real-Time Graph and set the trigger on **o03-Reference speed value after ramp**.
Set the "**Post trigger points**" to 90% and the "**sample time**" to 0.5 ms.
Click [Start] to start a new acquisition.

Give the run command, wait for the execution of the step response (in Real-Time Graph "**Monitoring**" become "**End acq**"), and then remove the run command.
Click [Download] to download the track (fig.12).

From the above figure you can see that:
- the real speed has no overshoot;

- when the system running at normal speed, the real speed does not reach the defined speed target.
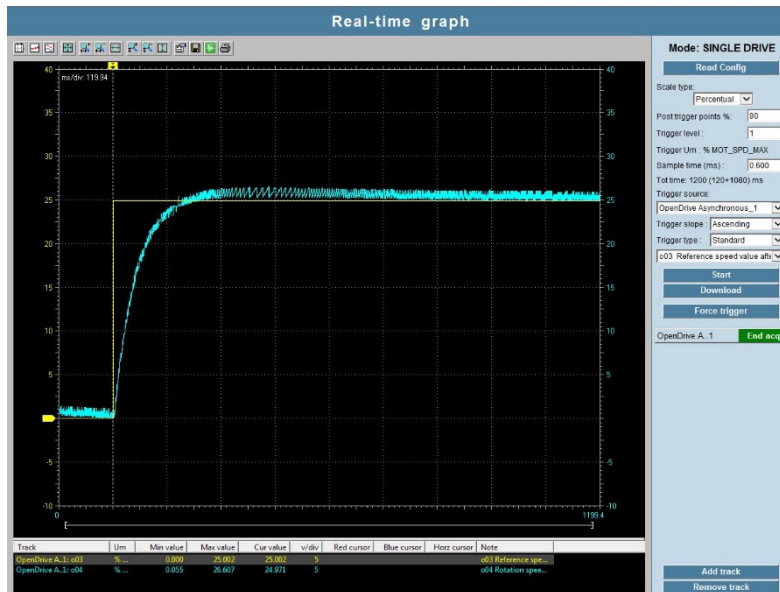

Fig. 12-Speed step response with initial parameters

Increase the proportional gain of "**P31 - KpV final speed regulator proportional gain**" in order to increase the response speed and increase the value of the filter time constant "**P33 - TfV final speed regulator (filter) time constant**" to reduce oscillations at high frequency.

To relaunch the test start a new acquisition with [Start], then give the run command.

From the figure 13 you can see that:
- the real speed has no overshoot;
- when the system is running at normal speed, the real speed gets very close to the defined speed target;
- the time needed to reach the speed target has reduced considerably.
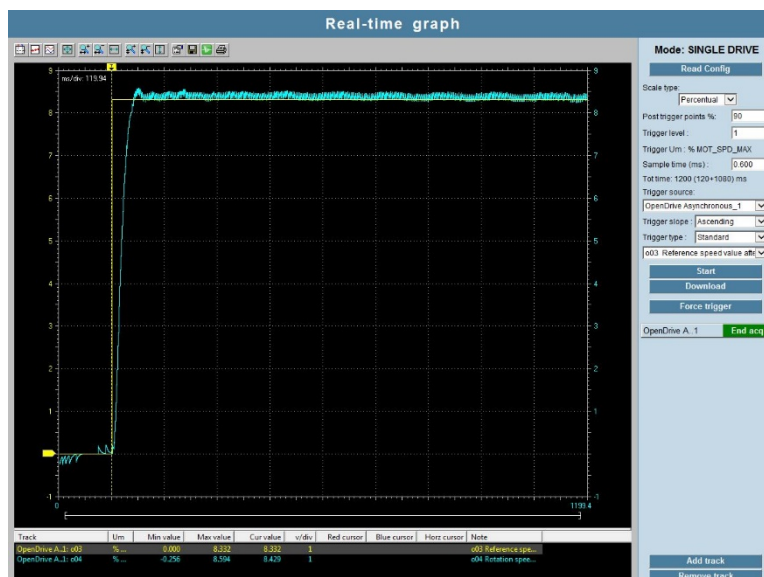
Fig. 13-Speed response with proportional gain and filther time calibrated

An excessively high proportional gain and filter time constant will lead to oscillations and overshoot in the speed response (fig.14).
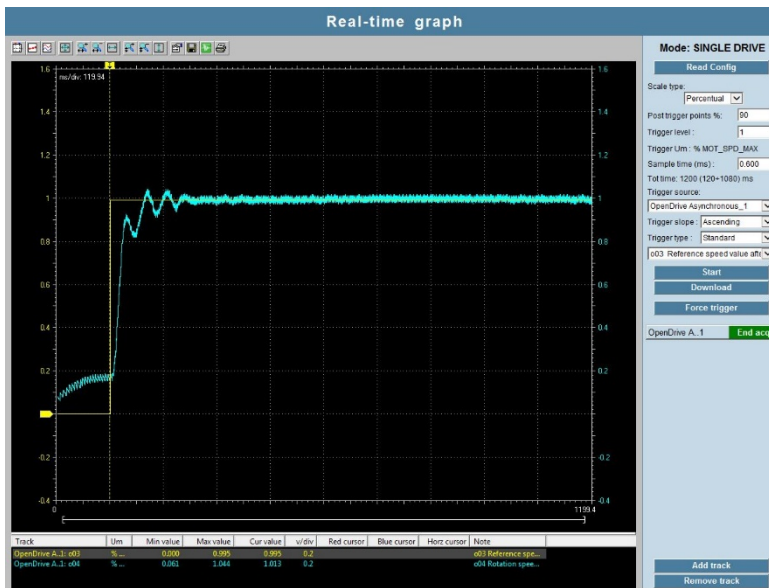
Fig. 14-Speed step response with excessively high speed gain and filter time constant

In order to reduce oscillations at high frequency, it's more convenient to reduce and balance the value of proportional gain "**P31 - KpV final speed regulator proportional gain**" and the filter time constant "**P33 - TfV final speed regulator (filter) time constant**" between them.

In order to get a null response at normal speed, (that is, the real speed is the same as the required speed), you will need to calibrate the "**P32 - TiV final speed regulator lead time constant**". Subsequently, reduce the lead time constant until the response at normal speed becomes null. Excessive reduction of the lead time constant will lead to overshoot and oscillations in the speed (fig.15).

Fig. 15-Speed response with lead time constant calibrated

Pay attention to the fact that the U01 parametr does not automatically return to **0-Not Enabled** at the end of the step response, this should be done by the user.

Save by pressing **Save Parameters to EEPROM** (equal to set **C63=1**). During saving drive's display will show "**BUSY**".

2.5 CORE AND APPLICATION UPDATING

If an upgrade of drive's software would be necessary, the first step is make sure that the OPDExplorer installed into the PC is the last version one (available on BDF DIGITAL website).

Remember that OPDExplorer installation has to be address to **C:** (not **C:\Program Files (x86)**).

After opening OPDExplorer, create a backup of the actual parameters recipe:
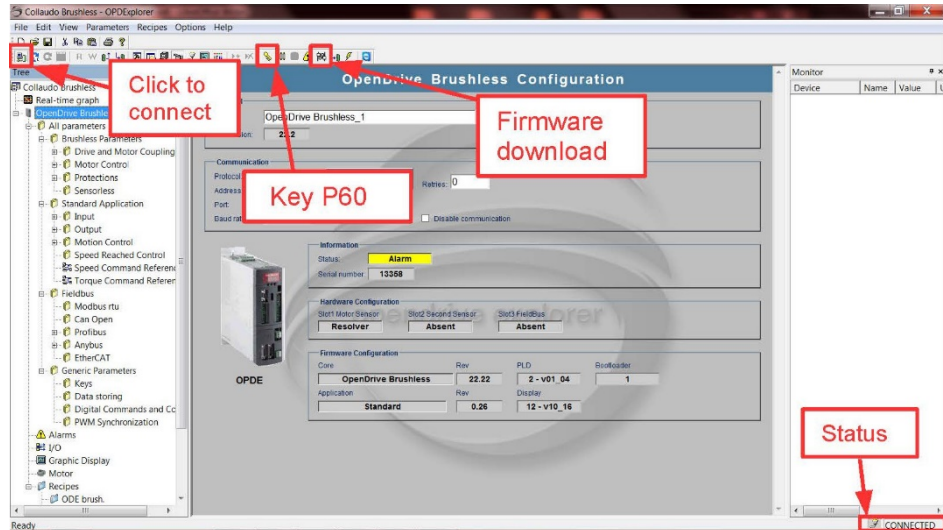
o   Click to connect to the drive;

Fig. 16-Connection to the drive

o   Click **Unlock Reserved Parameters** (equal to parameter P60) and write **95**;
o   Read all the parameters by **Read All** ;
o   Save the project (file .TCN) by File\Save As.

The last version of OPDExplorer allows to verify what is the last firmware version (file .ldr) available, inside the folder:

C:\BDF DIGITAL\Catalog\OpenDrive\firmware.
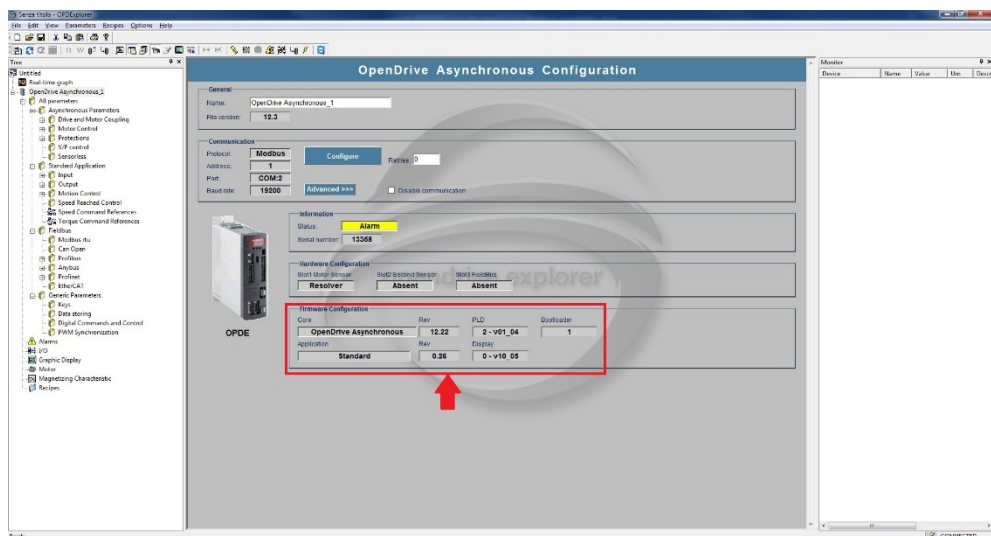
Fig. 17-Drive SW version

Upgrade steps:

- o Open a new project by selecting **File > New**. Create a new project selecting the application (standard or not-standard) of interest. This will automatically create a project with the updated version of the core and the application selected.

- o Click **Unlock Reserved Parameters** 🗝 (equal to parameter P60) and write **95**.

- o Press the **Firmware Download** 🎛 icon. The OPDDownloader/Uploader window will

  appear. Press the **File select…** 🔵 icon and select the directory where the latest core are located (.ldr files). Usually, the path to be followed to reach that directory is

C:\BDF DIGITAL\Catalog\OpenDrive\firmware
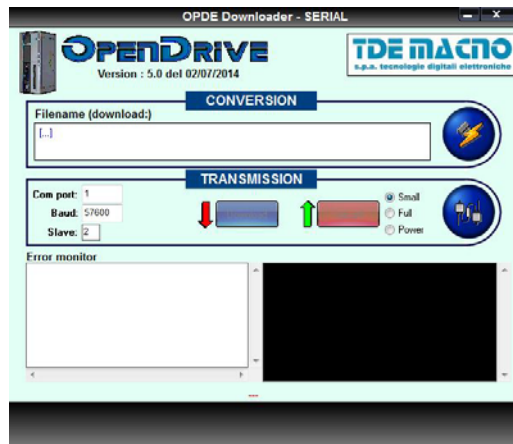
Fig. 18-OPDE Downloader

If the "Core" that is installed in the drive is an older revision than the revisions that have been found in the firmware directory, proceed with the updating, that is, select the latest revision and press **Open**. Make sure that "Com port", "Baud" and "Slave" are set correctly and finally

press **Download** ⬇ Download . The core download procedure may take some minutes.

- o Once the application has been selected, the **PLC Download** 🔌 icon will appear. Pressing this button will start the download of the application.
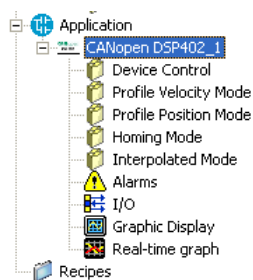

Fig. 19-Application selection

For the standard application, the "Application" icon will not appear. To download the application, just press PLC Download
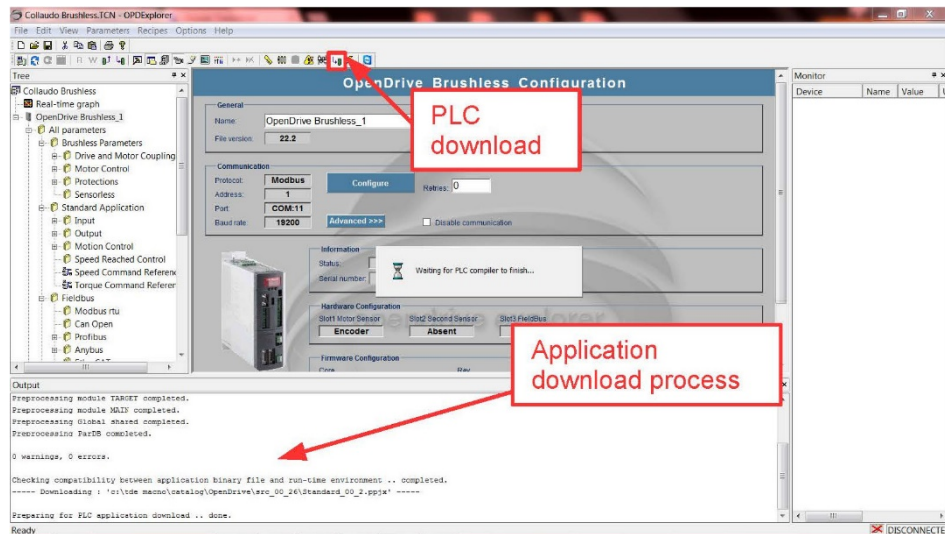
Fig. 20-Application download

  o   Turn the drive off and then on again.

When all the upgrading steps are over is necessary load the default parameters.

Click **Unlock Reserved Parameters** 🔑 (equal to parameter P60) and write **95**.
Make sure that the key **TDE_PAR_KEY** (**P99**) **= 0**. This key is in the folder:

All Parameters > Generic Parameters > Keys

Then set the parameter **DEF_PAR_RD** (**C61**) to **Yes** and press **Write Parameters** W.
DEF_PER_RD is located in:

All Parameters > Generic Parameters > Data Storing

Save by pressing **Save Parameters to EEPROM** (equal to set **C63=1**). During saving drive's display will show "**BUSY**".
Turn the drive off and then on again.
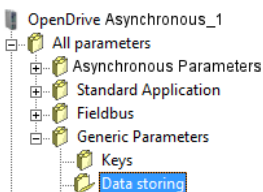
If default parameters are loaded when the key P99=82 sensitive data as drive size (P113) and factory calibrations (for example P105) will be lost.

If this updated drive will be used for the same actual application, is necessary to restore the parameters recipe by the backup .TCN file:

Open the initial .TCN project and connect the drive. An alarm windows will show, click **OK** to continue.

Open the key **P99=82** and write all the parameters with **Write-All** ↳.
In this way all the initial parameters of the drive is restore.

Save by pressing **Save Parameters to EEPROM** (equal to set **C63=1**). During saving drive's display will show "**BUSY**".
Turn the drive off and then on again.