PROFIBUS Manual

DUET_FL 48/10

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1 General

1.1 Documentation

This manual describes the field bus connection of DUET_FL 48/10 FB servo positioning controllers under PROFIBUS-DP. It describes the adjustment of the physical parameters, the activation of the PROFIBUS communication, the integration into the master connection and the communication with the servo positioning controller. It is intended for persons who are familiar with this servo positioning controller model.

It contains safety notes which have to be complied with.

Further information can be found in the following manual:

❖ **User Manual "DUET_FL 48/10, DUET_FL 48/10 IC, DUET_FL 48/10 FB":** Description of the device functionality and the software functions of the firmware including RS232 communication. Description of the DUET_FL ServoCommander™ parameterisation program with instructions concerning the start-up of DUET_FL 48/10 servo positioning controllers and description of the technical specifications and the device functionality as well as notes on the installation and the operation of the servo positioning controller DUET_FL 48/10.

1.2 PROFIBUS documentation

PROFIBUS (**PRO**cess **FI**eld**BUS**) is a standard defined by the German association of PROFIBUS users (PROFIBUS Nutzerorganisation e.V.). A complete description of the field bus system can be found in the following standard:

IEC 61158 „Digital data communication for measurement and control – Fieldbus for use in industrial control systems": This standard is divided into several parts and defines 10 "Fieldbus Protocol Types". Among these types, PROFIBUS is specified as type 3. PROFIBUS comes in two versions. One is PROFIBUS-DP for quick data exchange in production and building automation (DP = decentralized peripherals). The standard also describes the integration of the system into the ISO/OSI network model.

Further information, contact addresses etc. can be found under **www.profibus.com**.

Further documentation (in German) concerning the use of PROFIBUS-DP:

1. PROFIBUS-DP
   Grundlagen, Tips und Tricks für Anwender
   Manfred Popp
   Hüthig-Verlag, Heidelberg 1998

2. Dezentralisieren mit PROFIBUS-DP
   Aufbau, Projektierung und Einsatz des PROFIBUS-DP mit Simatic S7
   Josef Weigmann, Gerhard Kilian
   Siemens, Erlangen/München 1998

3. Der neue Schnelleinstieg für PROFIBUS DP
   Von DP-V0 bis DP-V2
   Manfred Popp
   PROFIBUS Nutzerorganisation e.V., Karlsruhe 2002

4. PROFIdrive – Profile Drive Technology,
   Vers. 3.1,
   PROFIBUS Nutzerorganisation e.V., Karlsruhe

5. IEC 61158 - Feldbus für industrielle Leitsysteme

2 Safety notes for electrical drives and controllers

2.1 Used symbols

	Information
	Important information and notes.

	Caution!
	Nonobservance may result in severe property damages.

	DANGER!
	Nonobservance may result in **property damages** and in **personal injuries**.

	Caution! Dangerous voltages.
	The safety note indicates a possible perilous voltage.

2.2 General notes

> In the case of damage resulting from non-compliance of the safety notes in this manual Motor Power Company Meßgeräte und Elektronik GmbH will assume any liability.

If the documentation in the language at hand is not understood accurately, please contact and inform your supplier.

Sound and safe operation of the servo drive controller requires proper and professional transportation, storage, assembly and installation as well as proper operation and maintenance. Only trained and qualified personnel may handle electrical devices:

TRAINED AND QUALIFIED PERSONAL

in the sense of this product manual or the safety notes on the product itself are persons who are sufficiently familiar with the setup, assembly, commissioning and operation of the product as well as all warnings and precautions as per the instructions in this manual and who are sufficiently qualified in their field of expertise:

❖ Education and instruction or authorisation to switch devices/systems on and off and to ground them as per the standards of safety engineering and to efficiently label them as per the job demands.

❖ Education and instruction as per the standards of safety engineering regarding the maintenance and use of adequate safety equipment.

❖ First aid training.

The following notes must be read prior to the initial operation of the system to prevent personal injuries and/or property damages:

> These safety notes must be complied with at all times.

> Do not try to install or commission the servo drive controller before carefully reading all safety notes for electrical drives and controllers contained in this document. These safety instructions and all other user notes must be read prior to any work with the servo drive controller.

> In case you do not have any user notes for the servo drive controller, please contact your sales representative. Immediately demand these documents to be sent to the person responsible for the safe operation of the servo drive controller.

If you sell, rent and/or otherwise make this device available to others, these safety notes must also be included.

The user must not open the servo drive controller for safety and warranty reasons.

Professional control process design is a prerequisite for sound functioning of the servo drive controller!

DANGER!

Inappropriate handling of the servo drive controller and non-compliance of the warnings as well as inappropriate intervention in the safety features may result in property damage, personal injuries, electric shock or in extreme cases even death.

2.3 Danger resulting from misuse

DANGER!

High electrical voltages and high load currents!

Danger to life or serious personal injury from electrical shock!

DANGER!

High electrical voltage caused by wrong connections!

Danger to life or serious personal injury from electrical shock!

DANGER!

Surfaces of device housing may be hot!

Risk of injury! Risk of burning!

DANGER!

Dangerous movements!

Danger to life, serious personal injury or property damage due to unintentional movements of the motors!

2.4 Safety notes

2.4.1 General safety notes

The servo drive controller corresponds to IP54 class of protection as well as pollution level 1. Make sure that the environment corresponds to this class of protection and pollution level.

Only use replacements parts and accessories approved by the manufacturer.

The devices must be connected to the mains supply as per EN regulations, so that they can be cut off the mains supply by means of corresponding separation devices (e.g. main switch, contactor, power switch).

Gold contacts or contacts with a high contact pressure should be used to switch the control contacts.

Preventive interference rejection measures should be taken for control panels, such as connecting contactors and relays using RC elements or diodes.

The safety rules and regulations of the country in which the device will be operated must be complied with.

The environment conditions defined in the product documentation must be kept. Safety-critical applications are not allowed, unless specifically approved by the manufacturer.

For notes on installation corresponding to EMC, please refer to User Manual of the servo positioning controller DUET_FL 48/10 FB. The compliance with the limits required by national regulations is the responsibility of the manufacturer of the machine or system.

The technical data and the connection and installation conditions for the servo drive controller are to be found in this product manual and must be met.

> **DANGER!**
>
> The general setup and safety regulations for work on power installations (e.g. DIN, VDE, EN, IEC or other national and international regulations) must be complied with.
>
> Non-compliance may result in death, personal injury or serious property damages.

Without claiming completeness, the following regulations and others apply:

VDE 0100 Regulations for the installation of high voltage (up to 1000 V) devices

EN 60204 Electrical equipment of machines

EN 50178 Electronic equipment for use in power installations

2.4.2 Safety notes for assembly and maintenance

The appropriate DIN, VDE, EN and IEC regulations as well as all national and local safety regulations and rules for the prevention of accidents apply for the assembly and maintenance of the system. The plant engineer or the operator is responsible for compliance with these regulations:

The servo drive controller must only be operated, maintained and/or repaired by personnel trained and qualified for working on or with electrical devices.

Prevention of accidents, injuries and/or damages:

Additionally secure vertical axes against falling down or lowering after the motor has been switched off, e.g. by means of:

> ➢ Mechanical locking of the vertical axle,
> ➢ External braking, catching or clamping devices or
> ➢ Sufficient balancing of the axle.

The motor holding brake supplied by default or an external motor holding brake driven by the drive controller alone is not suitable for personal protection!

Render the electrical equipment voltage-free using the main switch and protect it from being switched on again until the DC bus circuit is discharged, in the case of:

> ➢ Maintenance and repair work
> ➢ Cleaning
> ➢ long machine shutdowns

Prior to carrying out maintenance work make sure that the power supply has been turned off, locked and the DC bus circuit is discharged.

Be careful during the assembly. During the assembly and also later during operation of the drive, make sure to prevent drill chips, metal dust or assembly parts (screws, nuts, cable sections) from falling into the device.

Also make sure that the external power supply of the controller (24V) is switched off.

The DC bus circuit or the mains supply must always be switched off prior to switching off the 24V controller supply.

Carry out work in the machine area only, if AC and/or DC supplies are switched off. Switched off output stages or controller enablings are no suitable means of locking. In the case of a malfunction the drive may accidentally be put into action.

Initial operation must be carried out with idle motors, to prevent mechanical damages e.g. due to the wrong direction of rotation.

Electronic devices are never fail-safe. It is the user's responsibility, in the case an electrical device fails, to make sure the system is transferred into a secure state.

The servo drive controller and in particular the brake resistor, externally or internally, can assume high temperatures, which may cause serious burns.

2.4.3 Protection against contact with electrical parts

This section only concerns devices and drive components carrying voltages exceeding 50 V. Contact with parts carrying voltages of more than 50 V can be dangerous for people and may cause electrical shock. During operation of electrical devices some parts of these devices will inevitably carry dangerous voltages.

DANGER!

High electrical voltage!

Danger to life, danger due to electrical shock or serious personal injury!

The appropriate DIN, VDE, EN and IEC regulations as well as all national and local safety regulations and rules for the prevention of accidents apply for the assembly and maintenance of the system. The plant engineer or the operator is responsible for compliance with these regulations:

Before switching on the device, install the appropriate covers and protections against accidental contact. Rack-mounted devices must be protected against accidental contact by means of a housing, e.g. a switch cabinet. The regulations VBG 4 must be complied with!

Always connect the ground conductor of the electrical equipment and devices securely to the mains supply. Due to the integrated line filter the leakage current exceeds 3.5 mA!

Comply with the minimum copper cross-section for the ground conductor over its entire length as per EN60617!

Prior to the initial operation, even for short measuring or testing purposes, always connect the ground conductor of all electrical devices as per the terminal diagram or connect it to the ground wire. Otherwise the housing may carry high voltages which can cause electrical shock.

Do not touch electrical connections of the components when switched on.

Prior to accessing electrical parts carrying voltages exceeding 50 Volts, disconnect the device from the mains or power supply. Protect it from being switched on again.

For the installation the amount of DC bus voltage must be considered, particularly regarding insulation and protective measures. Ensure proper grounding, wire dimensioning and corresponding short-circuit protection.

2.4.4   Protection against electrical shock by means of protective extra-low voltage (PELV)

All connections and terminals with voltages between 5 and 50 Volts at the servo drive controller are protective extra-low voltage, which are designed safe from contact in correspondence with the following standards:

International: IEC 60364-4-41

European countries within the EU: EN 50178/1998, section 5.2.8.1.

> **DANGER!**
>
> High electrical voltages due to wrong connections!
>
> Danger to life, risk of injury due to electrical shock!

Only devices and electrical components and wires with a protective extra low voltage (PELV) may be connected to connectors and terminals with voltages between 0 to 50 Volts.

Only connect voltages and circuits with protection against dangerous voltages. Such protection may be achieved by means of isolation transformers, safe optocouplers or battery operation.

2.4.5 Protection against dangerous movements

Dangerous movements can be caused by faulty control of connected motors, for different reasons:

❖ Improper or faulty wiring or cabling

❖ Error in handling of components

❖ Error in sensor or transducer

❖ Defective or non-EMC-compliant components

❖ Error in software in superordinated control system

These errors can occur directly after switching on the device or after an indeterminate time of operation.

The monitors in the drive components for the most part rule out malfunctions in the connected drives. In view of personal protection, particularly the danger of personal injury and/or property damage, this may not be relied on exclusively. Until the built-in monitors come into effect, faulty drive movements must be taken into account; their magnitude depends on the type of control and on the operating state.

DANGER!

Dangerous movements!

Danger to life, risk of injury, serious personal injuries or property damage!

For the reasons mentioned above, personal protection must be ensured by means of monitoring or superordinated measures on the device. These are installed in accordance with the specific data of the system and a danger and error analysis by the manufacturer. The safety regulations applying to the system are also taken into consideration. Random movements or other malfunctions may be caused by switching the safety installations off, by bypassing them or by not activating them.

2.4.6 Protection against contact with hot parts

DANGER!

Housing surfaces may be hot!

Risk of injury! Risk of burning!

Do not touch housing surfaces in the vicinity of heat sources! Danger of burning!

Before accessing devices let them cool down for 10 minutes after switching them off.

Touching hot parts of the equipment such as the housing, which contain heat sinks and resistors, may cause burns!

2.4.7 Protection during handling and assembly

Handling and assembly of certain parts and components in an unsuitable manner may under adverse conditions cause injuries.

> **DANGER!**
>
> Risk of injury due to improper handling!
>
> Personal injury due to pinching, shearing, cutting, crushing!

The following general safety notes apply:

Comply with the general setup and safety regulations on handling and assembly.

Use suitable assembly and transportation devices.

Prevent incarcerations and contusions by means of suitable protective measures.

Use suitable tools only. If specified, use special tools.

Use lifting devices and tools appropriately.

If necessary, use suitable protective equipment (e.g. goggles, protective footwear, protective gloves).

Do not stand underneath hanging loads.

Remove leaking liquids on the floor immediately to prevent slipping.

3 Wiring and pin assignment

3.1 Pin assignment

The PROFIBUS interface in the servo positioning controller DUET_FL 48/10 FB is in accordance with EN 50170 as 5-pin M12 plug (b-codes, at the technology plug-in module, as socket and as plug)
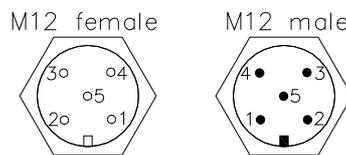
pin	color of conductor	Signal Profibus
1	-	+5V
2	green	A-line
3	-	0V
4	red	B-line
5	-	shield

Figure 3.1: PROFIBUS connector for DUET_FL 48/10 FB

PROFIBUS wiring

Because of the very high baud rates we recommend using standardized cables and connectors. They offer additional diagnose functionalities and facilitate rapid analysis of the field bus hardware in the event of malfunctions.

When setting up the PROFIBUS network, compliance with the information given in the standard literature and the following information and notes is strongly recommended in order to obtain a stable, trouble-free system. Improper wiring may lead to problems with the PROFIBUS causing the servo positioning controller to automatically deactivate itself while signalling an error.

3.2 PROFIBUS cable

PROFIBUS cable:

Bus cable PROFIBUS: Socket straight, shielded M12-B-codiert, 2-pole

Pin straight, shielded M12-B-codiert, 2-pole

Manufacturer: Phoenix Contact

order number:	length in m
15 18 10 6	0,3
15 18 11 9	0,5
15 18 12 2	1
15 18 13 5	2
15 18 14 8	5
15 18 15 1	10
15 18 16 4	15

3.3 Termination and bus terminating resistors

Every bus segment of the PROFIBUS network has to be equipped with bus terminating resistors to minimize line reflections, to guarantee practically constant load behaviour on the bus and to adjust a defined rest potential on the line. Termination has to be provided at the **beginning** and at the **end of every bus segment**.

The terminating resistors of the PROFIBUS module of the servo positioning controller DUET_FL 48/10 FB are already integrated in the module so that external connections (special connectors) are not required. The terminating resistors can be activated by setting the two DIP switches on the module (switches set to ON).Due to the high class of protection of the servo positioning controller DUET_FL 48/10 FB the terminating resistors can not served from outside. To switch on/off the terminating resistors is only possible, if the servo positioning controller DUET_FL 48/10 FB is removed from the motor.

Therefore a terminal resistance in form of a M12 of plug is recommended to use.

> **Bus terminating resistors**
>
> The DIP switches for activating the bus terminating resistors are already integrated on the technological modules.

External connection is also possible. The power supply of 5 V required for the externally connected terminating resistors is supplied to the PROFIBUS connector of the module (see pin assignment).

> Faulty or improper bus termination is the most common cause of errors in the event of malfunctions.

If the adjusted baud rate is > 1.5 MBaud, connectors with integrated line inductors (110 nH) have to be used because of the capacitive load of the device and the resulting line reflections.

4 PROFIBUS-DP and PROFIdrive

4.1 Overview of DP and its different versions

The DP communication protocol (DP = decentralized peripherals) is intended for quick data exchange on the field level. On this level, central automation devices, such as PLC, PC or process control systems communicate via a quick serial connection with decentralized field devices, such as I/O devices, drives, valves, measuring transducers and analysis devices. Data exchange with the decentralized devices is mainly cyclic. The required communication functions are defined by the DP basic functions (version DP-V0).

To meet special requirements of different areas of application, the basic functions of DP were extended and special functions were added so that now three versions of DP, i.e. DP-V0, DP-V1 and DP-V2, are available. Every version has a special main focus. They can be described as follows:

❖ DP-V0   This version offers the basic functionality of DP, such as cyclic data exchange and station-, module- and channel-specific diagnosis.

❖ DP-V1   This version includes extensions for process automation like, for example, acyclic data exchange for parameterisation, operation, monitoring and alarm management of intelligent field devices in parallel to cyclic exchange of useful data. Bus devices can be accessed online through engineering tools. In addition, DP-V1 includes alarms like the status alarm, the update alarm and a manufacturer-specific alarm.

❖ DP-V2   This version includes further extensions and is mainly intended to meet the requirements of drive applications. Additional functions such as, for example, isochronous slave operation and slave-to-slave communication allow DP-V2 to be used as a drive bus for controlling quick sequences of motion in drive shafts.

This version requires special hardware. At present, the control systems and target applications of the servo positioning controller DUET_FL 48/10 FB is not equipped with this hardware. This is why support of DV-V2 is not intended.

The versions of DP are specified in detail in IEC 61158 (see *chapter 1.2 PROFIBUS documentation*).

Every DP system comprises different types of devices. Three types can be distinguished: DP master class 1, DP master class 2 and DP slaves. DP can be used to realize mono- and multi-master systems and thus offers a high level of flexibility for system configuration. A maximum of 126 devices (masters or slaves) can be connected to the bus.

Due to the extensive diagnosis functions of DP, errors can be localized very quickly. Diagnosis messages are transmitted on the bus and collected at the master.

DP master class 1 (DPM1) is a central control system which exchanges information cyclically with decentralized stations (slaves) in a defined message cycle. Typical DPM1 devices are programmable logic controls (PLCs) or PCs, for example.

DP master class 2 (DPM2) devices are engineering, project or operating devices. They are used for start-up, maintenance and diagnosis, to configure the connected devices, to evaluate measured values and parameters and to check the device status. A DPM2 device does not have to be permanently connected to the bus system.

A slave is peripheral device (I/O device, drive, etc.) which reads in process information and/or uses output information to intervene in the process. In terms of communication, slaves are passive devices as they reply only to direct requests from a DPM1 or DPM2 device.

4.2 Basic functions of DP-V0

The central control system (master) cyclically reads the input information from the slaves and cyclically writes the output information to the slaves. The bus cycle time should be shorter than the program cycle time of the central automation system which is in the range of about 10 ms for many applications. A high data throughput alone is not enough for successful use of a bus system. Other factors, such as ease of operation, good diagnosis facilities and a fail-safe transmission method are more important. These characteristics have been combined successfully in DP-V0.

DP needs only about 1 ms to transmit 512 bits of input data and 512 bits of output data distributed to 32 connected devices. DP transmits input and output data in a message cycle. Useful data are transmitted using the SRD service (Send and Receive Data Service) of ISO/OSI layer 2.

To transmit data using the DP-V0 service, the amount and the meaning of the data to be transmitted have to be defined both for the master and for the slave. When a PROFIBUS connection is configured, the user has to make this definition before the field bus connection can be parameterized at both ends.

4.3 PROFIdrive overview

The "PROFIBUS profile for drive technology" or short PROFIdrive is a manufacturer standard for implementing PROFIBUS interfaces for drives. It has been defined by the association of PROFIBUS users. Just like CANopen, its aim is to offer the user a defined interface for programming servo controllers. This interface should be as manufacturer-independent as possible.

PROFIdrive specifies the configuration, diagnosis, data exchange and state machines with a PROFIBUS master. Furthermore, so-called application classes are defined. There are different

versions of the PROFIdrive specification with significant differences. The servo positioning controller DUET_FL 48/10 FB follows exclusively version 3.1 (see *chapter 1.2 PROFIBUS documentation)*.

The PROFIdrive specification (see *chapter 1.2 PROFIBUS documentation*) also defines a state machine for device control. This state machine is addressed using a control word and a status word. The meaning of the individual bits is also defined in the specification. The functions of these two words have been adopted to a large extent. Manufacturer-specific deviations are related to certain details and documented and marked in one of the following chapters.

The servo positioning controller DUET_FL 48/10 FB covers a part of the application classes defined in the PROFIdrive specification.

PROFIBUS-DP does not specify the form and meaning of the useful data themselves. This is why the concept of parameter numbers (PNUs) has been adopted for a PROFIBUS connection. These parameter numbers have an optional subindex and there are pre-defined or reserved areas among these PNUs. In addition, there is room for manufacturer-specific PNUs.

5 PROFIBUS connection

5.1 Introduction

Several steps are required to set up a functional PROFIBUS connection. Some of these settings should or even have to be made prior to activating the PROFIBUS communication. This chapter provides an overview of the required steps. The exact procedure is described in the following chapters.

With the DP-V0 service, data are transmitted in the form of so-called telegrams. The amount of data to be transmitted and their meaning have to be defined for the master and the slave prior to starting the data exchange.
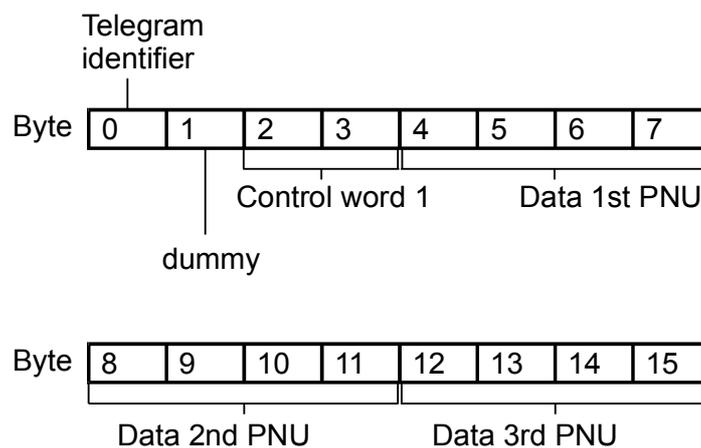
Figure 5.2: Example of the telegram format for the DUET_FL 48/10 FB

Figure 5.2 shows the example of a standard servo positioning controller DUET_FL 48/10 FB telegram sent from the master to the slave. Apart from the identifier in byte 0, this telegram type requires the PROFIdrive control word 1 in byte 2 and 3 for device control. The content of the other bytes can be configured as desired. In this example, 3 additional data are transmitted, each comprising 4 bytes. This results in a total length of 16 bytes for the telegram.

The user has to make this definition when planning the PROFIBUS connection prior to parameterizing the field bus connection at both ends. The slave should be parameterized first, and then the master. If the parameterisation is correct, the application is immediately ready for operation without any communication error.

5.2 Slave overview

This section provides an overview of slave-related steps for parameterisation and configuration. As some parameters do not become effective until after storage and reset, the following procedure is recommended:

1. Telegram configuration using the Telegram editor, *chapter 6*

2. Selection and parameterisation of Physical units, *chapter 7*

3. Configuration and activation of Operating parameters, *chapter 8*

The meaning of the data at the slave end is defined by entering parameter numbers (PNUs). This is done with the help of the **telegram editor** of the DUET_FL ServoCommander™ parameterisation program. The number of bytes for the PNU is automatically displayed. As a reference, the telegram editor also displays the total length of the telegram.

Important process data with regard to position, speed and acceleration are handed over in the form of **physical units**. These units should be parameterized prior to starting the communication as they define the way the data are interpreted in the servo positioning controller.

Once these steps have been completed, the **operating parameters** of the PROFIBUS connection have to be set. The slave address has to be set correctly prior to activating the communication. Additional options for controlling the address allocation can be activated through an external connection.

5.3 Master overview

This section provides an overview of master-related steps for parameterisation and configuration. The following procedure is recommended:

1. Installation of the **GSD file**

2. Indication of the **slave address**

3. Configuration of the **input and output data**

At the master end, the servo positioning controller has to be integrated into the PROFIBUS. To do so, the **GSD file** has to be installed if this has not been done already. Then the address for the slave and the input and output data have to be configured.

This is now described as an example for the integration under SIEMENS SIMATIC S7.

To integrate the servo positioning controller into the PROFIBUS network, the controller has to be selected in the hardware catalogue. Drag the "DUET_FL FB" folder to the PROFIBUS-DP master system. The **slave address** is inquired immediately afterwards.

Next, the bitmap of the servo positioning controller is displayed at the master system and has to be highlighted. After that, the length of the **input and output data** has to be defined. The associated modules are already prepared in the GSD file. One module for input data and one module for output data with the desired length have to be added to one port.
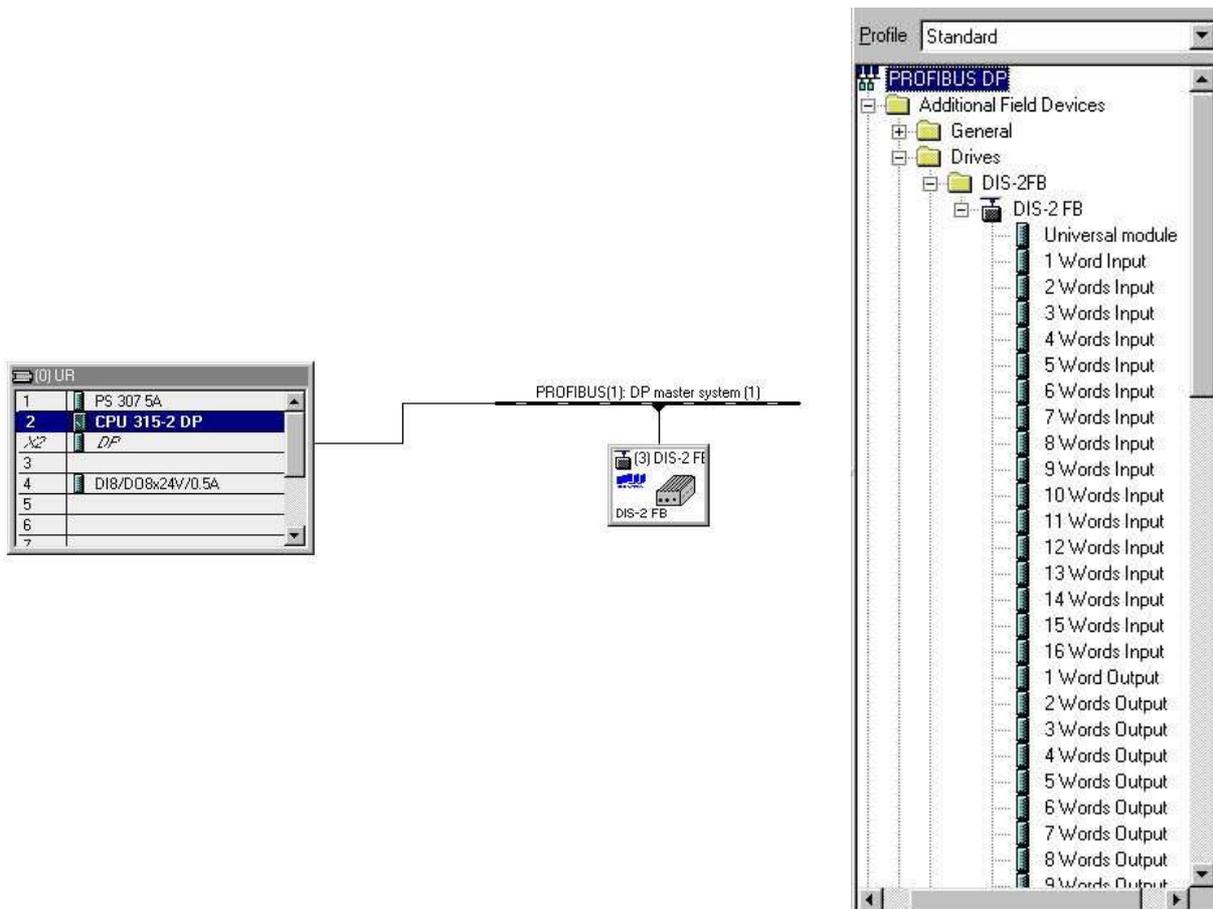
Figure 5.3: Hardware configuration under SIEMENS S7

> To ensure trouble-free operation, we recommend defining separate areas for input data and output data (see the example above).

Further information concerning the hardware configuration can be found in *chapter 6 **Telegram editor*** or in *chapter 13 Function and data blocks for SIEMENS S7* or in the Application Note together with complete example projects including function and data blocks for SIMATIC S7.

6 Telegram editor

6.1 Introduction

The telegram editor is used to define the way the servo positioning controller interprets the data received and sent. The firmware of DUET_FL 48/10 FB servo positioning controllers supports the exchange of data using the DP-V0 service. The data are exchanged cyclically in the form of so-called telegrams. The following telegram types can be distinguished:

❖ **Reception telegrams**:   Data sent from the master to the slave, also called **output data**.

❖ **Response telegrams:**   Data to be sent from the slave to the master, also called **input data**.

A telegram can contain 10 entries maximum.

In the project of the PROFIBUS master, data areas, e.g. data blocks, are created. The input and output data of the master and of the slave are stored in these data areas. During project planning, the user has to define the contents and their order as well as the size of the two data areas in an identical manner for both the master and the slave.

This parameterisation should be performed prior to activating the communication.

6.2 Reception telegrams

The servo positioning controllers DUET_FL 48/10 FB supports 2 reception telegrams. The following table shows how the different reception telegrams are connected to specific operating modes:

Telegram	Operating mode
Reception telegram 0	Positioning
Reception telegram 1	Speed control

Once a corresponding telegram identifier is read in the servo positioning controller, a check is performed and the associated operating mode is parameterized.

The necessary parameter numbers have to be entered for every reception telegram. They include the information concerning the meaning of the data in the telegram. In the case of reception telegrams 0..2, a so-called control word is entered at address 2 (length: 2 bytes). This consistent convention facilitates the creation of applications and the use of the Motor Power Company example projects for SIEMENS SIMATIC S7. The other entries can be chosen as desired from the object directory of the parameter numbers. The only thing that has to be considered is whether they are suitable. It is, for instance, not possible to enter pure actual value data into reception telegrams.

As far as reception telegrams are concerned, the associated response telegrams have to be selected, too. The user can specify and configure a specific response telegram for every reception telegram. In most cases, however, it is easier to use the same response telegram for all operating modes (reception telegrams 0..2). This reduces the necessary programming workload at the master end. In addition, the master usually requires the same actual value data from the servo positioning controller in all operating modes.

Figure 6.4 shows the example of reception telegram 0 (positioning mode). The entries can be highlighted and changed directly or deleted successively starting with the last entry. When an entry is highlighted, an additional field is displayed into which the parameter number can be entered. New telegram entries are added to the end. An additional diagnostic information is displayed above the button „Change entry" if a communication could have been established between Master and Slave. The really configured length of the telegram from Master to Slave is displayed.

Figure 6.4: Composition of a reception telegram

The example telegram in Figure 6.4 transmits the following parameters:

Address	Content (parameter number)	Description
0	Identifier (= 0xE0)	Fixed identifier
1	8-bit placeholder (PNU 2010 0)	free
2	Control Word 1 (PNU 967 0)	Control word for device control, has to be under this address
4	Target position (PNU 1001 0)	Target position, indication with the physical unit of a position set for PROFIBUS
8	Profile velocity (PNU 1001 1)	Profile velocity during positioning, indication with the physical speed unit set for PROFIBUS
12	Acceleration (PNU 1001 5)	Combination of the values for acceleration and deceleration, indication with physical unit for acceleration set for PROFIBUS

Detailed information on parameter numbers can be found in *chapters 9 Device control,*
10 Manufacturer-specific parameter numbers and *12 Profile-specific parameter numbers*.

6.3 Response telegrams

The firmware of the servo positioning controller DUET_FL 48/10 FB supports 2 response telegrams.

The necessary parameter numbers have to be entered for every response telegram. They include the information concerning the meaning of the data in the telegram. In the case of reception telegrams 0..2, a so-called status word is entered at address 2 (length: 2 bytes). This consistent convention facilitates the creation of applications and the use of the Motor Power Company example projects for SIEMENS SIMATIC S7. The other entries can be chosen as desired from the object directory of the parameter numbers. The only thing that has to be considered is whether they are suitable. It is, for instance, not possible to enter write-only parameters into response telegrams.

Figure 6.5 shows the example of response telegram 0 (positioning mode). The entries can be highlighted and changed directly or deleted successively starting with the last entry. When an entry is highlighted, an additional field is displayed into which the parameter number can be entered. New telegram entries are added to the end. An additional diagnostic information is displayed above the button „Change entry" if a communication could have been established between Master and Slave. The really configured length of the telegram from Master to Slave is displayed.
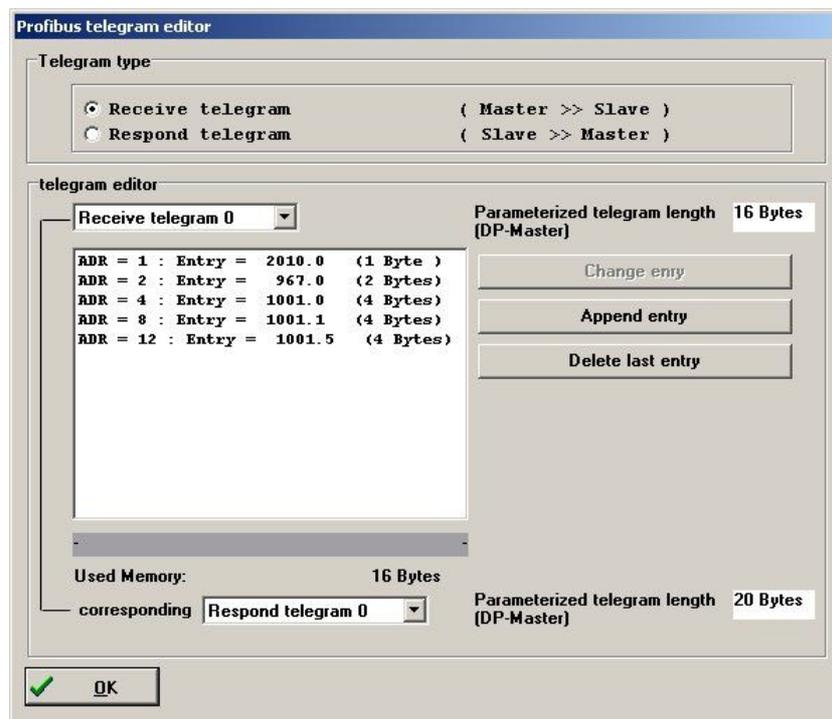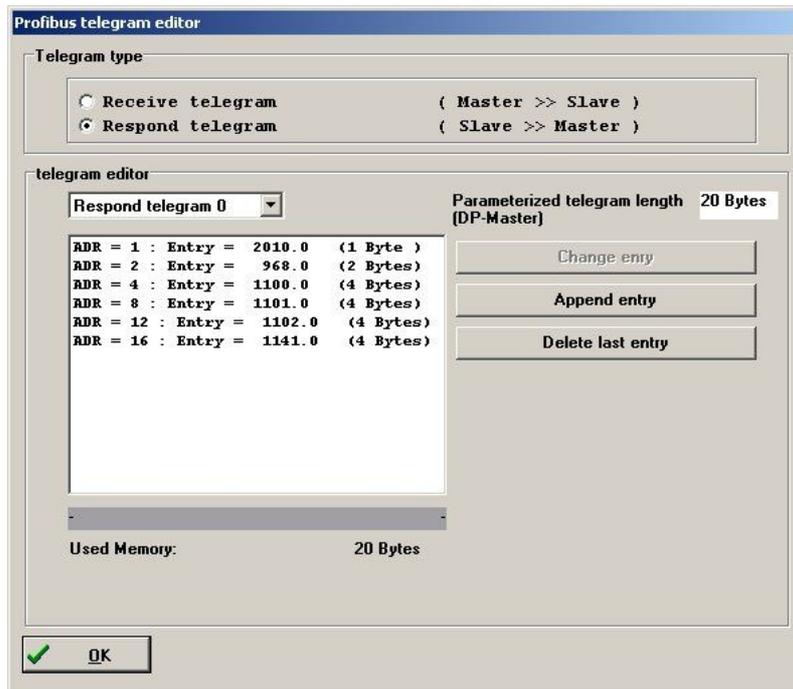
Figure 6.5: Composition of a response telegram

The telegram shown in Figure 6.5 transmits the following parameters:

Address	Content (parameter number)	Description
0	Identifier (= 0xF0)	Fixed identifier
1	Operating mode (PNU 1500 0)	Current operating mode of the servo positioning controller
2	Status word 1 (PNU 968 0)	Status word for device control, has to be under this address
4	Position actual value (PNU 1100 0)	Current actual position, indication with the physical unit of a position set for PROFIBUS
8	Velocity actual value (PNU 1101 0)	Current actual speed value, indication with the physical speed unit set for PROFIBUS
12	Current actual value (PNU 1102 0)	Actual value of the current, indicated per thousand referring to the nominal motor current
16	Digital inputs (PNU 1141 0)	Current status of the digital inputs, see for the meaning of the bits in the detailed description of the PNU.

Detailed information on parameter numbers can be found in *chapters 9 Device control, 10 Manufacturer-specific parameter numbers, 11 Operating modes* and *12 Profile-specific parameter numbers*.

7 Physical units

For trouble-free operation, the units of the process data transmitted on the field bus have to be defined. They can be set in the menu **Physical units Profibus** called by **Parameters/Fieldbus/Profibus**. **The parameters of the physical units should be set once and then remain unchanged during a running application.**

Unit-related factors are calculated internally so that all the user has to do is to select the desired unit. The gear ratio and the feed constant are stated as separate parameters.

Figure 7.6 shows the physical unit set-up menu of the DUET_FL ServoCommander™ program.
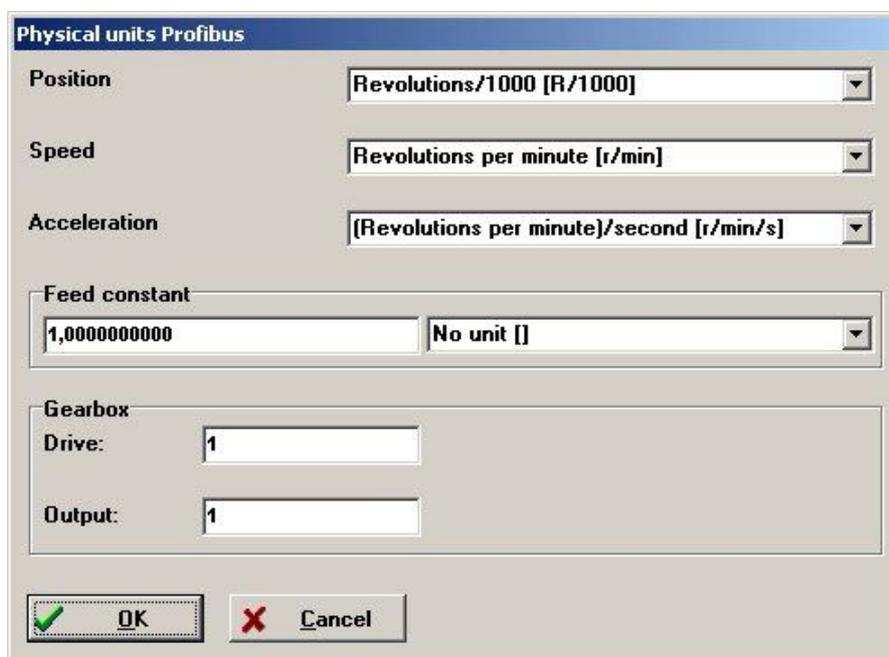
Figure 7.6: Setting of physical units

When the physical units are entered, the firmware automatically calculates conversion factors. They consist of a numerator and a denominator which can comprise a maximum of 32 bits each. If an overflow occurs when the factors are entered, the value will be rejected. In this case, the factors or the physical units have to be corrected.

It has to be taken into consideration that some quantities cannot always be used in a sensible manner. A purely rotative system, for example, does not require a feed constant. Apart from this, the feed constant has a physical unit. If this unit is not parameterized correctly, the feed constant will be ignored.

Example:

1. Position in revolutions, feed constant in mm/revolution:

   => The feed constant will be **ignored**.

2. Position in mm, feed constant without a unit:

   => The feed constant will be **considered** like a gear ratio.

3. Position in mm, feed constant in µm/revolution

   => The feed constant will be **considered** with the factor 1000.

> The value of the feed constant will be ignored for the associated physical unit, if the feed constant has a translatory unit and a rotary unit has been selected for the physical quantity.

Problems might arise during operation only if the internal value or the value entered externally cannot be represented following the conversion. In such a case, an error is issued and the setting of the physical units has to be checked.

During the parameterisation of the display units intermediate states may occur in which the physical units have an overflow. This case generates the error 59 "general arithmetic error". Perform Save & Reset in order to find out if the parameterisation is really invalid. If no error 59 is active after Reset, the settings are valid.

> Perform Save & Reset if an error 59 occurs during the parameterisation of the physical units. The physical units are valid if there is no error after Reset.

Figure 7.7 shows the interpretation of the gear ratio. In the menu **Physical units Profibus** of the ServoCommander™ parameterisation program, the value "Ingoing shaft" refers to U_{EIN}, the value "Outgoing shaft" to U_{AUS}.
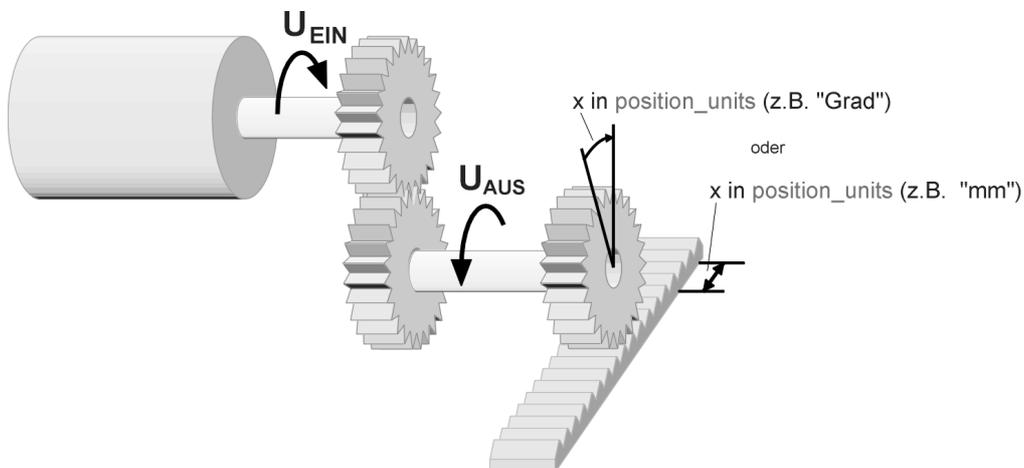
Figure 7.7: Gear ratio

Example:

If the motor performs 10 revolutions and a gear connected to the output performs one revolution, this corresponds to the following entries:

Ingoing shaft: 10

Outgoing shaft: 1

Now the system can be parameterized using the units of the output (outgoing shaft).

The gear ratio and the feed constant are defined as positive values.

If the orientation of the application has to be changed, this can be done in the software DUET_FL ServoCommander™ in the window „commands ".

8 Operating parameters

This chapter describes all the necessary measures to set up a communication using PROFIBUS-DP. The parameters described in the following sections are set via the serial interface using the DUET_FL ServoCommander™ program.

8.1 PROFIBUS operating parameters

At the servo positioning controller end, only the slave address has to be entered to configure the communication. After this, the communication can be activated. It has to be taken into consideration that the PROFIBUS communication is not activated until a reset is performed. Deactivation, however, is always done immediately. Figure 8.8 shows the window of the parameterisation program used to set the operating parameters.
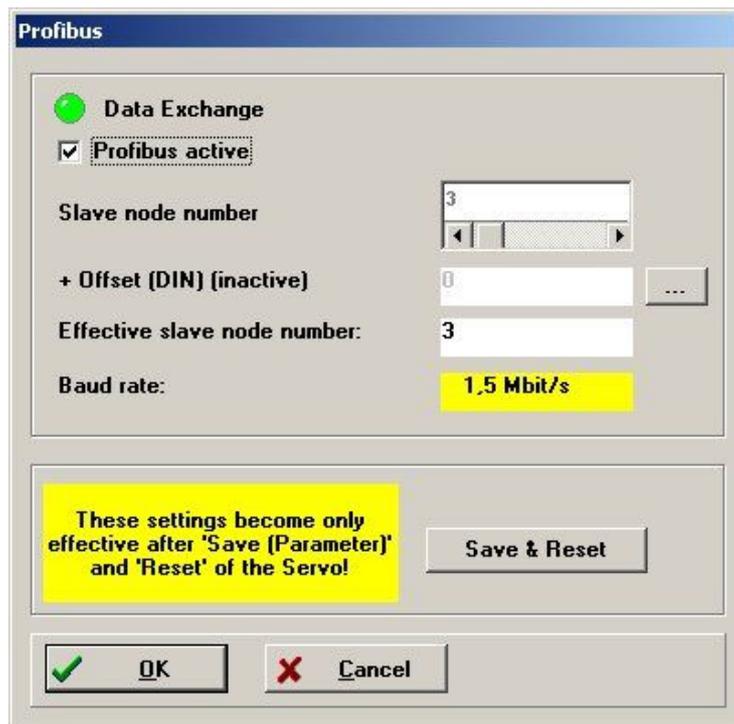
Figure 8.8: Setting of operating parameters

When the communication has been activated, the base value of the slave address can no longer be changed.

Starting at the base value, it is possible to increase the slave address using options and a suitable hardware connection. The digital inputs DIN0..3 and the analogue inputs AIN1 and AIN2 are intended for this purpose. The states of the inputs are read once immediately after a reset and used to calculate the effective slave address. Later changes have no effect. The options have different values:

Option	Active at	Value
Addition of DIN0..5	+ 24 V DC	0..63
Addition of DIN4 + 5	+ 24 V DC	16, 32, 48

The baud rate of the PROFIBUS communication is automatically recognized by the hardware used. The automatically detected baud rate is displayed in this menu if a connection between Master and Slave could have been established successfully. The following baud rates are supported by servo positioning controllers of the DUET_FL 48/10 FB product range:

Baud rate
9.6 kBaud
19.2 kBaud
45.45 kBaud
93.75 kBaud
187.5 kBaud
500.0 kBaud
1.5 MBaud
3.0 MBaud
6.0 MBaud
12.0 MBaud

9 Device control

9.1 Overview

To make the control of a field device (slave) independent from the various manufacturers, two data words have been specified in the PROFIdrive specification (1.2). **Control word 1** is used to control the major device functions by the master whereas the status of the device is read back in s**tatus word 1**. The PROFIdrive profile defines the order in which certain bits have to be set, e.g. to enable the power stage of the servo controller.

Device control of servo positioning controllers DUET_FL 48/10 FB follows the state diagram specified in the PROFIdrive profile. The implementation and potential manufacturer-specific deviations are described in detail in *chapter 9.4 State diagram and device control*.

The implementation of the control word and the status word only follows the PROFIdrive specification. Deviations from the specifications are marked. In addition, some bits have different meanings depending on the operating mode. In the following chapters, first the control word and then the status word are described. Then the device control mechanism using these two data words is explained.

9.2 Control word 1

Control Word 1 is used to control various device functions, e.g. controller enabling. Some bits have corresponding meanings. The use of these bits is described in *chapter 9.4 State diagram and device control*. The meaning of the individual bits follows the PROFIdrive profile. In addition, some functions are a manufacturer-specific and some bits have a manufacturer-specific functionality.

PNU	967
Subindex	**0**
Name	Control word 1
Data type	UINT16
Access	rw
Unit	-
Value range	-
Default value	0

In reception telegrams 0..2, control word 1 is bound to a fixed position. The system evaluates the control word always as the last datum. This means that new target positions are written first. A command to start a positioning run, which is transmitted simultaneously, therefore always refers to the data transmitted in the same telegram.

Some bits have different meanings depending on the operating mode. The two following tables show the meanings for the two operating modes.

Bit	Meaning	Behaviour
0	ON / OFF (OFF 1)	See the "Device control" section, *chapter 9.4 State diagram and device control*
1	No coast stop (no OFF 2) / coast stop (OFF 2)	
2	No quick stop (no OFF 3) / quick stop (OFF 3)	
3	Enable Operation / Disable Operation	
4*	1: Enable ramp generator 0: Reset ramp generator	1: All speed setpoints enabled 0: All speed setpoints disabled
5*	1: Unfreeze ramp generator 0: Freeze ramp generator	1: Setpoint ramp enabled 0: Ramp stopped (frozen)
6*	1: Enable setpoint 0: Disable setpoint	1: All setpoint inputs for the ramp enabled 0: All setpoint inputs for the ramp deactivated
7	Fault acknowledge (edge from 0->1)	Active errors are acknowledged if possible
8*	Jog 1 ON / Jog 1 OFF	The speed of motion of the "positive jogging" position set is preset as a speed setpoint through the ramp
9*	Jog 2 ON / Jog 2 OFF	The speed of motion of the "negative jogging" position set is preset as a speed setpoint through the ramp
10	1: Control by PLC 0: No control by PLC	1: Control word evaluated 0: Control word not evaluated
11*	Device-specific	free
12-15	Device-specific	free

*: Different meaning in another operating mode.

Table 9.1: Control word 1 for speed control mode

Bit	Meaning	Behaviour
0	ON / OFF (OFF 1)	See the "Device control" section, *chapter 9.4 State diagram and device control*
1	No coast stop (no OFF 2) / coast stop (OFF 2)	
2	No quick stop (no OFF 3) / quick stop (OFF 3)	
3	Enable Operation / Disable Operation	
4*	1: Do not reject traversing task 0: Reject traversing task	0: The current positioning run is cancelled or no positioning is started 1: No action
5*	1: No intermediate stop 0: Intermediate stop	0: No action or no positioning is started 0 ->1: Acceleration to motion speed in accordance with the current position set 1: No action 1 -> 0: Stopping with deceleration in accordance with current position set
6*	0 -> 1: Activate traversing task ***	Manufacturer-specific implementation: 0 -> 1: Start of the positioning run under the set position data set[1] if boundary conditions[2] are fulfilled
7	Fault acknowledge (edge from 0->1)	Active errors are acknowledged if possible
8*	Jog 1 ON / Jog 1 OFF	Manufacturer-specific implementation: 0 -> 1: Start of positioning in accordance with "positive jogging" position set 1 -> 0: Stop with deceleration in accordance with "positive jogging" position set
9*	Jog 2 ON / Jog 2 OFF	Manufacturer-specific implementation: 0 -> 1: Start of positioning in accordance with "negative jogging" position set 1 -> 0: Stop with deceleration in accordance with "negative jogging" position set
10	1: Control by PLC 0: No control by PLC	1: Control word evaluated 0: Control word not evaluated
11*	Start / Stop homing procedure	1: (No action) Continue homing 1 -> 0: Homing still active: Termination of homing without error Homing already terminated: No action 0: No action 0 -> 1: Start of homing[3]
12**	Relative / absolute	At positioning start: 1: Relative positioning 0: Absolute positioning
13**	Interrupt current positioning / add	At positioning start: 1: Interrupt current positioning, immediately start new positioning. 0: Add positioning to the end of the running positioning
14,15	Device-specific	

*:   Different meaning in another operating mode.
**:   Manufacturer-specific bit
***: Manufacturer-specific deviation from PROFIdrive specification

Table 9.2: Control word 1 for positioning mode

Notes concerning Table 9.2:

[1]:   The command "Activate traversing" starts the position set selected through PNU 1002 0. If the PROFIBUS position set is started, the current options of control word 1 will be adopted. Otherwise the options of the corresponding position set will take effect.

[2]:   The following boundary conditions apply to the start of a positioning:
  - Bit 4 = 1 (Do not reject traversing task)
  - Bit 5 = 1 (No intermediate stop)
  - No homing active

[3]:   Parameterizable options are taken into account, e.g. "with following positioning".

Chapter 9.4 State diagram and device control describes the device control. The servo positioning controller takes on various states. Defined transitions can be performed between these states. The transitions are triggered by so-called commands through bits 0..3. The commands are described in detail in *chapter 9.4 State diagram and device control*. The following tables shows an overview of the commands:

Command:	Bit 3 0008_h	Bit 2 0004_h	Bit 1 0002_h	Bit 0 0001_h	State transitions
OFF	×	**1**	**1**	**0**	1, 5, 11
ON	×	**1**	**1**	**1**	2
Coast Stop	×	×	**0**	×	6, 7, 8
Quick Stop	×	**0**	**1**	×	9, 10, 12
Disable Operation	**0**	**1**	**1**	**1**	4
Enable Operation	**1**	**1**	**1**	**1**	3

Table 9.3: Overview of all commands (× = not relevant)

> As some state transitions take a certain time, all status changes that are triggered through **control word 1** have to be read back through **status word 1**. It is only when the requested status can also be read in **status word 1**, that another command can be written in through **control word 1**.

9.3 Status word 1

Status word 1 reflects various device states, e.g. an active controller enabling. Some bits have corresponding meanings. All this is described in *chapter 9.4 State diagram and device control.* The meaning of the bits follows the PROFIdrive profile. In addition, some functions are manufacturer-specific and some bits have a manufacturer-specific functionality.

PNU	968
Subindex	0
Name	Status word 1
Data type	UINT16
Access	ro
Unit	-
Value range	-
Default value	-

In response telegrams 0..2, status word 1 is bound to a fixed position.

Some bits have different meanings depending on the operating mode. The two following tables show the meaning for the two operating modes.

Bit	Meaning	Behaviour
0	1: Ready To Switch On 0: Not Ready To Switch On	See the "Device control" section, *chapter 9.4 State diagram and device control*
1	1: Ready To Operate 0: Not Ready To Operate	
2	1: Operation Enabled 0: Operation Disabled	
3	1: Fault Present 0: No Fault Present	1: Active faults 0: No fault active
4	1: No OFF2 0: OFF2	1: No OFF2 command active 0: OFF2 command (control word 1, power stage OFF) active
5	1: No OFF3 0: OFF3	1: No OFF3 command active 0: OFF3 command (control word 1, quick stop) active
6	1: Switching On Inhibited 0: Switching On Not Inhibited	See the "Device control" section
7	1: Warning Present 0: No Warning Present	1: Active warning and/or setpoint disabling through limit switch active in at least one direction of rotation 0: No warning active
8*	1: Speed error within tolerance range 0: Speed error out of tolerance range	1: The actual speed is within the parameterizable message window around the target speed 0: The actual speed is out of the parameterizable message window around the target speed
9	1: Control by PLC 0: No control by PLC	Mirroring of bit 10 of control word 1
10*	1: f or n reached 0: f or n not reached	1: Actual speed > freely parameterizable reference speed[1] 0: Actual speed < freely parameterizable reference speed[1]

11-13*	Device-specific	Free
14-15	Device-specific	Free

*: Different meaning in another operating mode.

Table 9.4: Status word 1 for speed control mode

[1]: For this comparison, the sign character is always taken into consideration, i.e. the comparison is not based on the sum of the actual speed and the reference speed.

Bit	Meaning	Behaviour
0	1: Ready To Switch On 0: Not Ready To Switch On	See the "Device control" section, *chapter 9.4 State diagram and device control*
1	1: Ready To Operate 0: Not Ready To Operate	
2	1: Operation Enabled 0: Operation Disabled	
3	1: Fault Present 0: No Fault Present	1: Active faults 0: No fault active
4	1: No OFF2 0: OFF2	1: No OFF2 command active 0: OFF2 command (control word 1, power stage OFF) active
5	1: No OFF3 0: OFF3	1: No OFF3 command active 0: OFF3 command (control word 1, quick stop) active
6	1: Switching On Inhibited 0: Switching On Not Inhibited	See the device control section
7	1: Warning Present 0: No Warning Present	1: Active warning and/or setpoint disabling through limit switch active in at least one direction of rotation 0: No warning active
8*	1: Following error within tolerance range 0: Following error out of tolerance range	1: No following error 0: Following error message active
9	1: Control by PLC 0: No control by PLC	Mirroring of bit 10 of control word 1
10*	1: Target position reached 0: Not at target position	1: The current positioning run has been completed and the actual position is within the target window 0: The current positioning run is still active or the actual position is not within the target window.
11*	1: Home position valid 0: Home position not valid	1: A homing run has been completed successfully 0: No homing run has been performed or the position information is invalid due to an error.
12*	Traversing Task Acknowledge	See detailed description
13*	1: Drive stopped 0: Drive in motion	1: The actual speed is within a fixed tolerance window around 0. No active positioning or active quick stop. 0: The actual speed is out of the tolerance window around 0 or the condition above is not fulfilled.
14-15	Device-specific	Free

*: Different meaning in another operating mode.

Table 9.5: Status word 1 for positioning mode

Just like the combination of several bits of **control word 1** can trigger several state transitions, the combination of several bits of **status word 1** can indicate the state of the servo positioning controller. The following table shows the possible states of the state diagram and the associated bit combination used to indicate the states in **status word 1**.

Status	Bit 6 0040$_h$	Bit 2 0004$_h$	Bit 1 0002$_h$	Bit 0 0001$_h$	Mask	Value
SWITCH_ON_INHIBITED	1	0	0	0	0047$_h$	0040$_h$
READY_FOR_SWITCHING_ON	0	0	0	1	0047$_h$	0001$_h$
SWITCHED_ON	0	0	1	1	0047$_h$	0003$_h$
OPERATION	0	1	1	1	0047$_h$	0007$_h$

Table 9.6: Device status ($\times$ = not relevant)

Bits 4 and 5 depend on the command and therefore are not included in Table 9.6.

9.4 State diagram and device control

This chapter describes how DUET_FL 48/10 FB servo positioning controllers are controlled with the help of the two data words "control word 1" (PNU 967) and "status word 1" (PNU 968), i.e. how the power stage is activated, for example. This control mechanism follows the specification of the PROFIdrive profile. The following terms are used for the explanation of the context:

State:	Depending on whether the power stage has been activated, for example, or whether a fault has occurred, the servo positioning controller is in different states. The states defined under PROFIdrive will be described in this chapter.
	Example: **SWITCHING_ON_INHIBITED**
State transition	Just like the states, also the transitions between the states are defined under PROFIdrive. Transition means getting from one state to another. The master triggers state transitions by setting bits in **control word 1**. The servo positioning controller can also trigger a state transition internally when it detects a fault.
Command	To trigger state transitions, certain combinations of bits have to be set in **control word 1**. Such a combination is referred to as a command.
	Example: **Enable Operation**
State diagram	The states and the state transitions form the state diagram, i.e. an overview of all states and possible transitions.

9.4.1 State diagram

The states have been taken over to a large extent from the PROFIdrive specification. PROFIdrive distinguishes between a ramp stop and a quick stop. In firmware 3.0, the controller enabling is deactivated in both cases so that the simplified state diagram shown in Figure 9.9 results.

After it has been switched on, the servo positioning controller initializes and finally reaches the **SWITCHING_ON_INHIBITED** state. The power stage is deactivated and the motor shaft can be rotated freely , if no holding brake in the motor. Via state transitions **1**, **2** and **3**, the **OPERATION** state is reached. This state corresponds to the controller enabling through PROFIBUS. In this state, the power stage is activated and the drive is controlled as defined by the operating mode set. Make sure that the servo positioning controller has been parameterized correctly and that an associated setpoint equals zero.
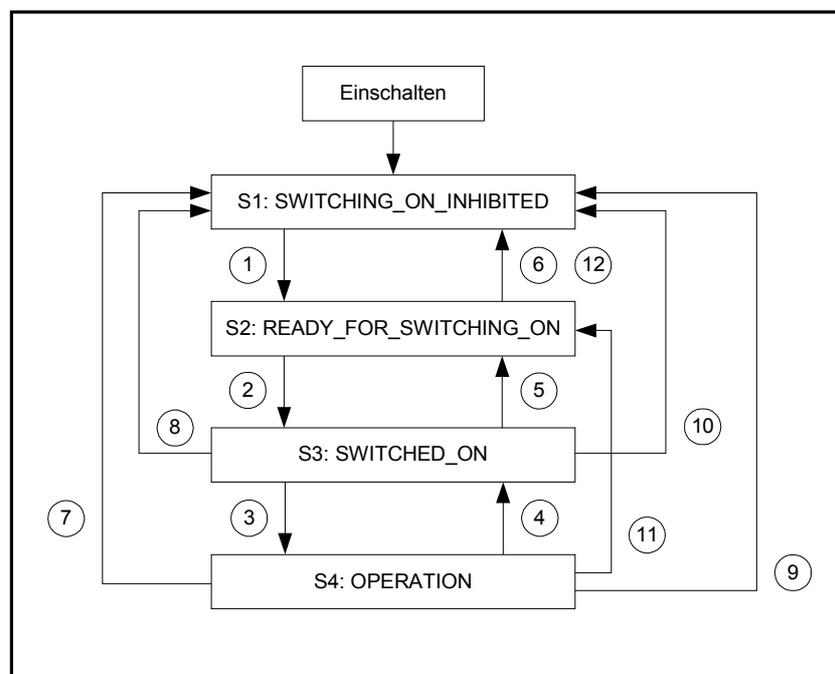
Figure 9.9: Simplified state diagram

State transition **4** corresponds to the cancellation of the controller enabling, i.e. a running motor is slowed down to standstill following a set emergency stop ramp. State transition **7** corresponds to the cancellation of the power stage enabling, i.e. a running motor would coast down in an uncontrolled manner.

If a fault occurs (no matter in which state), the system is led to the **SWITCHING_ON_INHIBITED** state. Depending on the severity of the fault, certain actions, e.g. an emergency stop, can be performed before this state is reached.

The states and their meanings are listed in the following table:

Name	Meaning
Switching on	The servo positioning controller performs a self-test. The PROFIBUS communication does not work yet.
SWITCHING_ON_INHIBITED	The servo positioning controller has completed its self-test. PROFIBUS communication is possible.
READY_FOR_SWITCHING_ON	The servo positioning controller waits until the digital inputs "power stage enable" and "controller enable" are connected to 24 V. (Controller enabling logic „Din9 and Profibus").
SWITCHED_ON	Power stage enabling is active.
OPERATION	The motor is connected to power and is controlled as defined by the operating mode.

9.4.2 Device control

To perform the state transitions described in *chapter 9.4.1 State diagram*, certain bit combinations have to be set in **control word 1** (see below). The lowest 4 bits of **control word 1** are evaluated together to trigger a state transition. In the following section, only the most important state transitions 1, 2, 3, 4, 7 and 11 are explained. A table showing all possible states and state transitions can be found in *chapter 9.4.3 Command overview*.

The first column of the following table shows the desired state transition, and the second column the requirements which have to be fulfilled for this transition (in most cases a command coming from the host, indicated by a frame in the table). The creation of this command, i.e. the bits which have to be set in **control word 1**, is shown in the third column (x = not relevant). Bit 10 in **control word 1** has always to be set to control the servo positioning controller. After the state transition, the new state can be recognised by evaluating the relevant bits in **status word 1.** This is shown in the last column.

No.	Will be performed if	Bit combination for control word 1					Action	Status word 1[1)]
		Bit	3	2	1	0		
1	Power stage and controller enabling present + no coast stop + no quick stop + command **OFF**	**OFF** =	x	1	1	0	None	0x0201
2	Command **ON**	**ON** =	0	1	1	1		0x0203
3	Command **Enable Operation**	**Enable Operation** =	1	1	1	1	Activation of power stage enabling and control in accordance with operating mode set	0x0207
4	Command **Disable Operation**	**Disable Operation** =	0	1	1	1	Cancellation of controller enabling	0x0203
11	Command **OFF**	**OFF** =	x	1	1	0	Cancellation of	0x0201

No.	Will be performed if	Bit combination for control word 1					Action	Status word 1[1]
		Bit	3	2	1	0		
							controller enabling	
7	Command **Coast Stop**	**Coast Stop** =	x	x	0	x	Power stage is disabled. The motor coasts down and can be rotated freely.	0x0250 or 0x0270

[1]: After completion of the state transition. The mask for the relevant bits is 0x0277

Table 9.7: Most important state transitions of the servo positioning controller

The following example shows the enabling of the servo positioning controller, i.e. the enabling of the controller via the PROFIBUS field bus:

EXAMPLE

The servo positioning controller is to be "enabled", i.e. the power stage and the controller enabling are to be activated via PROFIBUS:

1.)   The servo positioning controller is in the **SWITCH_ON_INHIBITED** state

2.)   The servo positioning controller has to change over to the **OPERATION** state

3.)   According to the state diagram (Figure 9.9), state transitions 1, 2 and 3 have to be performed.

4.)   The following results from Table 9.7:

  Transition 1: Control Word 1 = 0406$_h$ New state: READY_FOR_SWITCHING_ON *[1]
  **   Status Word 1 = 0x0201**
  Transition 2: Control Word 1 = 0407$_h$ New state: SWITCHED_ON *[1]
  **   Status word 1 = 0x0203**
  Transition 3: Control Word 1 = 040F$_h$ New state: OPERATION *[1]
  **   Status Word 1 = 0x0207**

Note:

1.)   The example assumes that no other bits are set in **control word 1**. Bit 10 must be set. Otherwise, only bits 0..3 are relevant for the transitions.

*[1] The master has to wait until the state can be read back in **status word 1** in the relevant bits (mask = 0x0277). This will be explained in detail later in this manual.

9.4.3 Command overview

The following table shows the commands for the state transitions described in *chapter 9.4.1 State diagram*:

No.	Will be performed if	Bit combination for control word 1					Action	Status word 1[1]
		Bit	3	2	1	0		
1	Power stage and con-	**OFF** =	x	1	1	0	None	0x0201

No.	Will be performed if	Bit combination for control word 1					Action	Status word 1[1]
		Bit	3	2	1	0		
	troller enabling present + no Coast Stop + no Quick Stop + command **OFF**							
2	Command **ON**	ON =	0	1	1	1		0x0203
3	Command **Enable Operation**	**Enable Operation** =	1	1	1	1	Activation of power stage enabling and Control in accordance with adjusted operating mode	0x0207
4	Command **Disable Operation**	**Disable Operation** =	0	1	1	1	Cancellation of controller enabling	0x0203
5	Command **OFF**	OFF =	x	1	1	0	Cancellation of controller enabling	0x0201
6	Command **Coast Stop**	**Coast Stop** =	x	x	0	x	None	0x0250 resp. 0x0270
7	Command **Coast Stop**	**Coast Stop** =	x	x	0	x	The power stage is disabled. The motor coasts down and can be rotated freely.	0x0250 resp. 0x0270
8	Command **Coast Stop**	**Coast Stop** =	x	x	0	x	Cancellation of power stage enabling	0x0250 resp. 0x0270
9	Command **Quick Stop**	**Quick Stop** =	x	0	1	x	Cancellation of controller enabling	0x0260
10	Command **Quick Stop**	**Quick Stop** =	x	0	1	x	Cancellation of controller enabling	0x0260
11	Command **OFF**	OFF =	x	1	1	0	Cancellation of controller enabling	0x0201
12	Command **Quick Stop**	**Quick Stop** =	x	0	1	x	Cancellation of controller enabling	0x0260

[1]: After completion of the state transition. The mask for the relevant bits is 0x0277

Table 9.8: Overview of all state transitions of the servo positioning controller

It has to be taken into consideration that some quantities do not always make sense. A purely rotatory system, for example, does not require a feed constant. Apart from that, the feed constant has a physical unit. If this unit has not be parameterized correctly, the feed constant will be ignored.

Power stage disabled...

...means that the power semiconductors (transistors) are no longer activated. **If this state is assumed while the motor is running, the motor will coast down.** A motor brake which might be present, will be put on automatically.

Caution: The signal does not guarantee that the motor is really disconnected from power.

Power stage enabled...

...means that the motor is controlled as defined by the selected operating mode. A motor brake which might be present will be released automatically. In the event of a defect or incorrect parameterisation (motor current, number of poles, encoder offset angle etc.) the drive might react in an uncontrolled manner.

10   Manufacturer-specific parameter numbers

10.1   Overview

The following table provides an overview of currently implemented PNUs:

PNU	Sub-index	Description	Type	Access
1000	0	Position set number (read/write)	UINT16	rw
1001	-	(Position data)		
	0	Target position	INT32	rw
	1	Profile velocity	INT32	rw
	3	Acceleration (positioning)	UINT32	rw
	4	Deceleration (positioning)	UINT32	rw
	5	Acceleration and deceleration (positioning)	UINT32	rw
	0	Start set number	UINT8	rw
1002	0	Profile type of the position sets	INT16	rw
1003	0	Target velocity	INT32	rw
1010	-	(Accelerations for velocity control)		
1011	0	Acceleration (velocity control)	UINT32	rw
	1	Deceleration (velocity control)	UINT32	rw
	2	All accelerations (velocity control)	UINT32	rw
	-	(Current limitation)		
1022	0	Selector for current limitation	INT8	rw
	1	read / write setpoint for current limitation	INT32	rw
	-	(Jogging)		
1040	0	Jogging velocities (symmetrical)	INT32	rw
	1	Jogging accelerations (symmetrical)	UINT32	rw
	0	Homing method	INT8	rw
1050	0	Homing offset	INT32	rw
1051	0	Position actual value	INT32	ro
1100	0	Velocity actual value	INT32	ro
1101	0	Current actual value	INT32	ro

1102	0	Digital outputs	UINT32	rw
1140	0	Digital inputs	UINT32	ro
1141	0	DC-bus voltage	UINT32	ro
1150	0	Power stage temperature	INT16	ro
1160	-	(Motor data)		
1290	0	I²t time motor	UINT16	rw
	1	I²t ratio motor	UINT16	ro
	0	Controller enable	UINT16	rw
1350	0	Operating mode	UINT8	ro
1500	-	(Error code)		
1601	0	Error field 0	UINT32	ro
	1	Error field 1	UINT32	ro
	-	(Error management)		
1610	0	Error number	UINT8	rw
	1	Error reaction code	UINT8	rw
	0	Entry for manufacturer specific PKW access	2 * UINT32	rw
2000	-	(Placeholder)		
2010	0	8-bit placeholder (blank element)	UINT8	rw
	1	16-bit placeholder (blank element)	UINT16	rw
	2	32-bit placeholder (blank element)	UINT32	rw
	0	32-bit placeholder (blank element)	UINT32	rw
2011				

10.2   PNUs for positioning mode

This section describes the parameters required for the positioning mode.

10.2.1 PNU 1000: Position Set Number

This parameter is used to select the position data set into which the data transmitted through PROFIBUS are entered. This parameter provides access to all position data sets of the servo positioning controller. Field bus data sets are often volatile data sets. The position data set for PROFIBUS, however, can be saved and parameterized with the help of the DUET_FL ServoCommander™ parameterisation program. In this way, parameters, which do not have to be changed in an application during operation, can be defined in a fixed manner. Accelerations, for example, can be entered once and then do not have to be transmitted.

PNU	1000
Subindex	0
Name	Position Set Number
Data type	UINT16
Access	rw
Unit	-
Value range	0 .. 68: 0..63: Standard position data sets 64 .. 67: Reserved 68: Position data set PROFIBUS
Default value	68 (Position data set PROFIBUS)

10.2.2 PNU 1001: Position Data

This parameter number is used to address parameters of the selected position data set. PNU 1000 is used for selection. The following parameters are available:

- Target position

- Profile velocity

- End velocity

- Acceleration and deceleration, either separately or combined for both accelerations

The data are interpreted in the way they were set as physical units. For this purpose, the DUET_FL ServoCommander™ parameterisation software opens a special window (see *chapter 7 Physical units*).

This PNU can also be used to parameterize parameters for jogging, for example. To do so, the position data set number has to be set accordingly. Then the jogging speed can be set with the help of the profile velocity.

PNU	1001
Name	Position Data

Subindex	0
Name	Target Position
Data type	INT32
Access	rw
Unit	Physical unit of PROFIBUS position
Value range	-
Default value	0

Subindex	1
Name	Profile Velocity
Data type	INT32
Access	rw
Unit	Physical unit of PROFIBUS velocity
Value range	-
Default value	1000 rpm

Subindex	3
Name	Acceleration Positioning
Data type	UINT32
Access	rw
Unit	Physical unit of PROFIBUS acceleration
Value range	-
Default value	10,000 (rpm)/s

Subindex	4
Name	Deceleration Positioning
Data type	UINT32
Access	rw
Unit	Physical unit of PROFIBUS acceleration
Value range	-
Default value	10,000 (rpm)/s

The parameter **All Accelerations Positioning** provides access to the acceleration and deceleration ramp. If the same value is intended for both parameters, only one data value has to be transmitted. This value is then used internally for both acceleration types. It has to be taken into consideration that during a read operation only the current value of the deceleration ramp is read. The user has to make sure that reading a value is sufficient. This can be ensured, for example, by reading a value once and then writing it back.

Subindex	5
Name	All Accelerations Positioning
Data type	UINT32
Access	rw
Unit	Physical unit of PROFIBUS acceleration
Value range	-
Default value	10,000 (rpm)/s

10.2.3 PNU 1002: Start Set Number

This parameter is used to select the position data set which is started through control word 1 following a positioning start command. The servo positioning controller contains up to 64 storable standard position data sets. These data sets can be selected unambiguously on the basis of 8 bits.

PNU	1002
Subindex	0
Name	Start Set Number
Data type	UINT8
Access	rw
Unit	-
Value range	0 .. 68 0..63: Standard position data sets 64..67: Reserved 68: Position data set PROFIBUS
Default value	68 (Position data set PROFIBUS)

10.2.4 PNU 1003: Position Profile Type

By using this parameter the jerk-free ramp is activated. The time is not adjustable. It is set automatically on the maximum time when activation.
If the time is changed by DUET_FL ServoCommander™ parameterisation software, the value which is read back via PROFIBUS supplies the value 2.

PNU	1003
Subindex	0
Name	Position Profile Type
Data type	UINT16
Access	rw
Unit	-
Value range	0, 2 0: Jerk free is disabled 2: Jerk free is enabled with the maximum time
Default value	0

10.2.5 PNU 1050: Homing Method

Set the homing method by this parameter number. Please refer to the USER Manual DUET_FL 48/10 FB for a detailed description of the homing methods.

PNU	1050
Subindex	0
Name	Homing Method
Data type	INT8
Access	rw
Unit	-
Value range	see USER Manual DUET_FL 48/10 FB
Default value	1

10.2.6 PNU 1051: Home Offset

Set the distance between the home position and the zero position of a homing process by this parameter number. Positive values move the zero position into positive direction referring to the home position. The following figure illustrates this by an example for the target „limit switch" and the zero pulse as zero position. The shown direction of the arrow displays the effective direction of the offset.

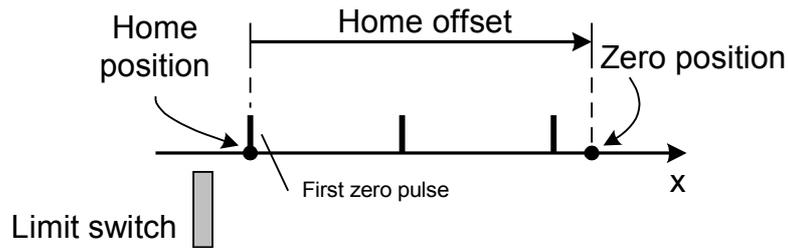**Figure 10.10:** Interpretation of the home offset

The data are interpreted in the physical unit PROFIBUS position. The physical unit can be set by an appropriate menu of the parameterisation program DUET_FL ServoCommander™.

PNU	1051
Subindex	0
Name	Home Offset
Data type	INT32
Access	rw
Unit	Physical unit PROFIBUS position
Value range	-
Default value	0

10.3   PNUs for speed control mode

This section describes the parameters required for the speed control mode.

10.3.1 PNU 1010: Target Velocity

This parameter set the speed setpoint via PROFIBUS. In speed control mode, the selector „speed setpoint " is selected automatically.

PNU	1010
Subindex	0
Name	Target Velocity
Data type	INT32
Access	rw
Unit	Physical unit of PROFIBUS velocity
Value range	-
Default value	0

10.3.2 PNU 1011: Accelerations for Velocity Control

Under this parameter number, the acceleration values for the speed control mode can be parameterized. The servo positioning controller defines 4 different acceleration ramps. As in most applications several ramps are parameterized in an identical manner, the following selections are possible:

- Acceleration, combined for positive and negative direction of rotation

- Deceleration, combined for positive and negative direction of rotation

- Combination of acceleration and deceleration for positive and negative direction of rotation

The data are interpreted in the way they were set as physical units. For this purpose, the DUET_FL ServoCommander™ parameterisation software opens a special window (see *chapter 7 Physical units*).

The parameter with subindex 0 and 1 provides access to the acceleration for both directions of rotation. Internally, it is always written to the accelerations for both directions of rotation. It has to be taken into consideration, that during a read operation only the current value of the acceleration ramp for a positive direction of rotation is read. The user has to make sure that reading a value is sufficient. This can be ensured, for example, by reading a value once and then writing it back.

PNU	1011
Name	Accelerations for Velocity Control

Subindex	0
Name	Acceleration Velocity Control
Data type	UINT32
Access	rw
Unit	Physical unit of PROFIBUS acceleration
Value range	-
Default value	10.000 (rpm)/s

Subindex	1
Name	Deceleration Velocity Control
Data type	UINT32
Access	rw
Unit	Physical unit of PROFIBUS acceleration
Value range	-
Default value	10.000 (rpm)/s

The parameter **All Accelerations Velocity Control** provides access to the acceleration and deceleration ramp for both directions of rotation. If the same value is intended for all 4 parameters, only one data value has to be transmitted. This value is then used internally for all four acceleration types. It has to be taken into consideration that during a read operation only the current value of the deceleration ramp for the positive direction of rotation is read. The user has to make sure that reading a value is sufficient. This can be ensured, for example, by reading a value once and then writing it back.

Subindex	2
Name	All Accelerations Velocity Control
Data type	UINT32
Access	rw
Unit	Physical unit of PROFIBUS acceleration
Value range	-
Default value	10.000 (rpm)/s

10.4   PNUs for Different Operating Modes

This section describes parameters which are not especially assigned to one single operating mode.

10.4.1 PNU 1022: Current Limitiation

The parameter **Current Limitiation** adjusted the torque limitation independently of the mode of operation.

The parameter **Limit Current Input Channel** is used to select the channel which limit the current. It can be selected between a direct value (RS232 or PROFIBUS) or a indirectly value over an analogue input.

Depending from the choosen selector, the parameter **Limit Current** set the value for current limit or the scaling factor for the analogue inputs.

- In the first case the moment is limited to the proportional current in mA
- In the second case the current is set to the value in mA which corresponds to 10V.

PNU	1022
Name	Current Limitiation

Subindex	0
Name	Limit Current Input Channel
Data type	INT8
Access	rw
Unit	-
Value range	0...3, 7
Default value	0

Value	Description
0	**no limitation**
1	**AIN0**
2	**AIN1**
3	**RS232**
7	**Profibus**

Subindex	1
Name	Limit Current
Data type	INT32
Access	rw
Unit	mA
Value range	0...40 A
Default-Wert	--

10.4.2 PNU 1040: Jogging

This parameter allows the simplified access of both velocities and all four acceleration values for jogging. By this, less data has to be transmit in the cyclic data telegram. Internally, all parameters are written.

PNU	1040
Name	Jogging

Subindex	0
Name	Jogging Velocity
Data type	INT32
Access	rw
Unit	Physical unit PROFIBUS velocity
Value range	-
Default value	100 rpm

Subindex	1
Name	Symmetrical Jogging Accelerations
Data type	UINT32
Access	rw The read access returns the value of the acceleration
Unit	Physical unit PROFIBUS acceleration
Value range	-
Default value	10.000 (rpm)/s

10.4.3 PNU 1290: Motor Data

Servo motors may be overloaded for a certain period of time. This parameter indicates how long the motor may receive the indicated maximum current. After the expiry of the I²t-time the current is automatically limited to the parametrized rated current in order to protect the motor. The default adjustment is 2 seconds and can be used for most motors.

The actual value of iit can be read via the object **iit ratio motor**.

PNU	1290
Name	Motor Data

Subindex	0
Name	iit Time Motor
Data type	UINT16
Access	rw

Unit	ms
Value range	0...10000
Default value	2000

Subindex	1
Name	iit Ratio Motor
Data type	UINT16
Access	ro
Unit	Promille
Value range	-
Default value	-

10.4.4 PNU 1350: Enable Logic

The parameter **enable_logic** gibt an wie die Reglerfreigabe erfolgen soll.

For safety reasons this is done automatically after activation of CANopen (also after a reset).

PNU	1350
Subindex	0
Name	Enable Logic
Data type	UINT16
Access	rw
Unit	-
Value range	0...3
Default value	0

Value	Description
0	Controller enable via digital input DIN 9
1	Controller enable via digital input DIN 9 + RS232
2	Controller enable via digital input DIN 9 + CAN
3	Controller enable via digital input DIN 9 + Profibus

10.5   Actual values

This section provides an overview of actual values which can be read with the help of parameter numbers.

10.5.1 PNU 1100: Position Actual Value

This parameter is used to return the actual position value. This value is scaled with the physical unit set for PROFIBUS.

The calculation of the actual position value of the servo positioning controller may has a greater value range than the range that can be transmitted through PROFIBUS by the PNU 1100.

PNU	1100
Subindex	0
Name	Position Actual Value
Data type	INT32
Access	rw
Unit	Physical unit of PROFIBUS position
Value range	-
Default value	-

10.5.2 PNU 1101: Velocity Actual Value

This parameter is used to return the actual speed value. This value is scaled with the physical unit set for PROFIBUS.

PNU	1101
Subindex	0
Name	Velocity Actual Value
Data type	INT32
Access	ro
Unit	Physical unit of PROFIBUS velocity
Value range	-
Default value	-

10.5.3 PNU 1102: Current Actual Value

This parameter is used to read the actual current value. When this value is returned, it is referred to the rated motor current.

PNU	1102
Subindex	0
Name	Current Actual Value
Data type	INT32
Access	ro
Unit	Parts per thousand with regard to the rated motor current
Value range	-
Default value	-

10.5.4 PNU 1140: Digital Outputs

The digital outputs can be set via the parameter **digital outputs**. It has to be kept in mind that a delay of up to 10 ms may occur between sending the command and a real reaction of the digital output. The time the outputs are really set can be seen by rereading the parameter.

PNU	1140
Subindex	0
Name	Digital Outputs
Data type	UINT32
Access	rw
Unit	-
Value range	-
Default value	0

Bit	Value	Description
0	00000001h	holding brake (read only)
0...15		reserved
16	00010000h	controller ready for operation (read only)
17,18	00060000h	DOUT1, DOUT2

10.5.5 PNU 1141: Digital Inputs

The parameter is used to read the state of the digital inputs. The available digital inputs depend on the parameterisation of the servo positioning controller.

PNU	1141
Subindex	0
Name	Digital Inputs
Data type	UINT32
Access	ro
Unit	-
Value range	-
Default value	-

Bit	Value	Digital Output
0	00000001h	Negativ limit switch (DIN7)
2	00000002h	Positiv limit switch (DIN8)
3	00000008h	Interlock (controller enable (DIN9) is missing)
16...25	03FF0000h	DIN0...DIN9

10.6   Parameters for the telegram structure

Due to certain technical requirements, some parameters cannot be stored under any random address in the storage area of the master. In addition to that, the length of the telegrams may differ although the same number of data is transmitted. This is why certain parameters have been defined to fill gaps, for example.

10.6.1 PNU 2000: PKW Access

Register this parameter into a telegram in order to variably access different parameter at runtime of the process. There is only one access at maximum available for the receive and response telegrams. Parameterize this access accordingly. Ensure that this access is registered in all receive and response telegrams.

The term PKW results from Parameter-Kennung-Wert (parameter - identification - value) stated in a former version of the PROFIdrive standard. There, the value for the identification was limited. Here the access is enlarged to higher parameter numbers.

PNU	2000	
Subindex	0	
Name	PKW Access (manufacturer specific)	
Data type	2 * UINT32 (8 Byte)	
Access	rw	
Unit	-	
Value range	Byte 0:	Access type:

		0x00: No access 0x41: Read access 0x42: Write access Other values: reserved
	Byte 1..2:	Parameter number
	Byte 3:	Subindex
	Byte 4..7:	Data
Default value	0	

10.6.2 PNU 2010: Placeholders

These parameters are used to fill up parameters. As a result, data areas (e.g. data blocks) can be structured such that parameters with a length of 2 or 4 bytes are located at even storage addresses.

PNU	**2010**
Name	Placeholder

Subindex	**0**
Name	8 Bit
Data type	UINT8
Access	rw
Unit	-
Value range	-
Default value	0

Subindex	**1**
Name	16 Bit
Data type	UINT16
Access	rw
Unit	-
Value range	-
Default value	0

Subindex	**2**
Name	32 Bit
Data type	UINT32
Access	rw
Unit	-
Value range	-
Default value	0

10.6.3 PNU 2011: Element 0

This parameter has basically the same purpose as the parameter PNU 2010 2. The only difference is that it is not shown in the telegram editor of the DUET_FL ServoCommander™ program, if it is entered at the end of a telegram. The number of entries in a telegram is limited to 10. Unused entries therefore contain this PNU.

PNU	2011
Subindex	0
Name	Element 0
Data type	UNT32
Access	rw
Unit	-
Value range	-
Default value	0

10.7   Parameter for Various Intents

This section contains parameters which are not explicitly assigned to a special function group.

10.7.1 PNU 1601: Last Error Code

This parameter number returns the last generated error.

With the parameters **error Field 0** and **error Field 1** the actual errors codes can be read out.

PNU	1601
Name	Error Code

Subindex	0
Name	Error Field 0
Data type	UINT32
Access	ro
Unit	-
Value range	see USER Manual DUET_FL 48/10 FB
Default value	-

Subindex	1
Name	Error Field 1
Data type	UINT32
Access	ro
Unit	-
Value range	see USER Manual DUET_FL 48/10 FB
Default value	-

10.7.2 PNU 1610: Error Managment

The parameter **error number** contains the error number, which is to be found in the DUET_FL ServoCommander ™ under „Error management…".

The parameter **Error Reaction Code** indicates the reaction of the servo positioning controller to different situations.

PNU	1610
Name	Error Management

Subindex	0
Name	Error Number
Data type	UINT8
Access	rw
Unit	-
Value range	1..64
Default value	-

Subindex	1
Name	Error Reaction Code
Data type	UINT8
Access	rw
Unit	-
Value range	0x00, 0x03, 0x05, 0x08
Default value	-

Value	Description
0x00	no reaction
0x03	warning (display)
0x05	brake with quick stop deceleration
0x08	power stage (motor coast off)

11 Operating modes

11.1 Overview

The servo positioning controllers DUET_FL 48/10 FB offer two operating modes via PROFIBUS:

❖ Speed control

❖ Positioning

Within the operating modes, different behaviour is the result of setpoint selectors which can be parameterized differently.

PROFIdrive (see *chapter 1.2 PROFIBUS documentation*) defines so-called application classes. These classes can be set using corresponding parameter numbers. To simplify this, the operating mode is linked to the cyclic reception telegrams. Following the PROFIdrive specification, the following operating modes and the associated reception telegrams are supported at present:

Operating mode	Reception telegram	Identifier
Positioning	0	0xE0
Speed control	1	0xE1

Other operating modes cannot be selected at present.

11.2 Parameters

The operating mode is continuously monitored or selected with the help of reception telegrams. The process of changing the operating mode requires several cycles of an internal function. This is why a manufacturer-specific parameter number has been defined to be able to read the current operating mode.

11.2.1 PNU 1500: Operating Mode

This manufacturer-specific parameter is used to set/read the operating mode. The operating mode is served regardless of the setpoint selectors. Other special features can be found in the associated chapters.

PNU	1500
Subindex	0
Name	Operating Mode
Data type	UINT8
Access	rw
Unit	-
Value range	0x08: Speed control 0x10: Positioning
Default value	-

11.3   Speed control mode

PROFIdrive defines special features for handling the setpoint. For this purpose, the meanings of the corresponding bits in control word 1 have been defined. The setpoint can be deactivated, for example, or the setpoint ramp can be stopped ("frozen").

11.4   Positioning mode

PROFIdrive defines special features concerning the behaviour in the positioning mode. For this purpose, the meanings of the corresponding bits in control word 1 have been defined. Homing controlled by the slave, for example, is started by a certain bit. Some features are now described in detail:

❖   All global options for homing are also valid when homing is started through the PROFIdrive control word 1. An optional following positioning to zero position is performed.

❖   Due to a manufacturer-specific implementation, positioning is started only on a rising edge of the associated bit in control word 1.

❖   Positioning is started even if no successful homing has been performed beforehand.

Other manufacturer-specific bits are defined in control word 1 in order to be able to perform optional relative or absolute positioning tasks.

❖   Distinction between absolute and relative positioning

❖   Definition as to whether at the start of a positioning run a running position has to be interrupted or whether the positioning run to the started has to be added to the running positioning.

Some applications require a sequence of motion tasks to be executed without interruption (see Figure 11.11).

❖ Interruption of the running positioning
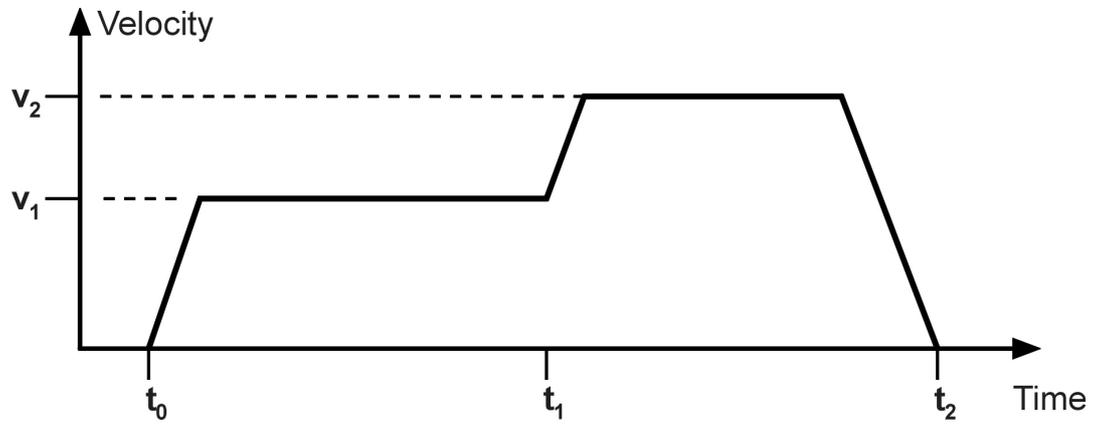
Figure 11.11: Uninterrupted sequence of motion tasks

12 Profile-specific parameter numbers

This chapter provides an overview of the parameter numbers (PNU) which were implemented following PROFIdrive.

12.1 Overview

The following table provides an overview of the implemented PNUs.

PNU	Sub-index	Description	Type	Access
967	0	Control word 1, see *chapter 9.2 Control word 1*	V2	rw
968	0	Status word 1, siehe *chapter 9.3 Status word 1*	V2	ro
971	0	Save parameters	UINT16	rw

Note: Data type V2 is defined as a bit sequence with a length of 2 bytes.

12.2 PNU description

The PNUs 967 and 968 are described in detail in *chapter 9 Device control*. The PNU 971 is described in the following chapter.

12.2.1 PNU 971: Transfer into a Non-Volatile Memory

Active different saving processes of parameters inside the servo positioning controller by this parameter number.

PNU	971	
Subindex	0	
Name	Transfer into a non-volatile memory	
Data type	UINT16	
Access	rw	
Unit	-	
Value range	0:	No action
	1:	Save the actual parameter set and all position data sets
	2.. 65535:	reserved
Default value	0	

13 Function and data blocks for SIEMENS S7

13.1 Overview

Special function blocks have been written for DUET_FL 48/10 FB servo positioning controllers and Siemens PLC systems (SIMATIC-S7 control systems). These functions blocks facilitate the integration of the servo positioning controllers into a PLC program with PROFIBUS functionality. The various function and data blocks (FD, DB) are assigned to one of the operating modes.

To make the use of the function blocks clearer, example programs were written.

> This chapter is intended to familiarise the user quickly with the functions of the inputs and outputs and the use of the FBs and DBs within the S7 environment. **However, this chapter does not replace the previous chapters of the PROFIBUS-DP Product Manual.**

The available example programs are only examples and explain the fundamental methods for using the function and data blocks.

When the example programs are used in customer-specific applications, the user has to check whether all function- and safety-relevant requirements have been fulfilled.

> **Information**
>
> Specific function and data blocks have been developed for the DUET_FL 48/10 FB servo positioning controllers. These function and data blocks are integrated in example programs and can be downloaded free of charge under **www.Motor Power Company.de**.

If one switches between the operating modes, one also has to switch between two function blocks. If the controller enabling shall remain active during switching between two function blocks, it might be necessary to modify the function blocks accordingly. Please contact the technical support department.

> **Attention**
>
> To switch from one operating mode to another, the current FB has to be deactivated and an FB of another operating mode has to be activated. As a result, the controller enabling might be deactivated.

13.2   Function and data blocks for DUET_FL 48/10 FB servo positioning controllers

13.2.1 Function block (FB) overview

The function blocks (FBs) are used to control the state diagram implemented in the servo positioning controller.

Status word 1 in byte 2/3 of the DB40 actual_value data block symbolizes the actual state of the servo positioning controller. Control word 1, which is contained in bytes 2/3 of every mode-specific telegram format and described by the FB, is used to control the servo positioning controller.

The master connection provides the PLC system in defined I/O areas with the input and output data of the servo positioning controllers. These data are read out of the slave through SFC14 and written to the slave through SFC15. SFCs 14 and 15 are system functions which **must** be used for consistent reading and writing of telegrams with a length > 4 bytes.

The data are stored in the data blocks defined for the operating mode in question through the corresponding SFCs. The SFCs are not integrated in the function blocks and **must** be loaded as S7 program elements.

In practice, the DBs are used as I/O modules to control the states of the servo positioning controller and to transmit data which have to be sent to the servo positioning controller.

Every operating mode and every servo positioning controller requires separate function blocks. If several servo positioning controllers are used in different operating modes, this might lead to bottlenecks concerning the storage utilization of the application.

Information	
The order of the data in the data blocks corresponds to the order defined in the telegram format of the associated operating mode (FB).	

13.2.2 FBs of DUET_FL 48/10 FB servo positioning controllers

13.2.2.1   FB_position (FB 41 positioning mode)

```
                    "FB_position"
        ... ─── EN

                 DB_nr_pos
        ... ─── ition

                 DB_nr_act
        ... ─── ual_value

                 drive_ena
        ... ─── ble

                 start_hom
        ... ─── ing

        ... ─── start_pos

        ... ─── abs_rel

                 change_im
        ... ─── mediatly    drive_ena
                             ble_ok      ─── ...
                 intermedi
        ... ─── ate_stop    home_vali
                             d           ─── ...
        ... ─── hold
                                 pos_ok  ─── ...
        ... ─── jog_pos
                             velo_zero   ─── ...
        ... ─── jog_neg
                                 fault   ─── ...
                 fault_res
        ... ─── et               ENO     ───
```
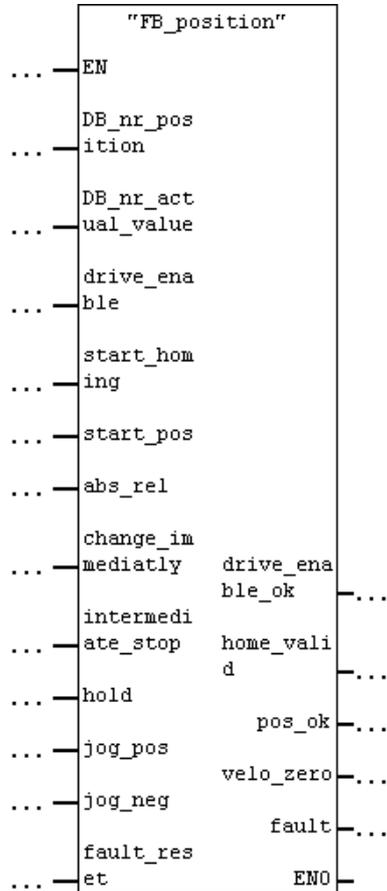
- **Parameters:**

    - **DB_nr_position:**

      Number of the data block containing the data for the positioning mode (INT).

    - **DB_nr_actual_value:**

      Number of the data block containing the actual value data (INT).

- **Inputs:**

    - **drive_enable:**

      This input is used to activate the controller enabling in the positioning mode. The drive is held in its position.

    - **start_homing:**

      This input is used to start a homing run. The motor is started. This requires an active controller enabling, i.e. the output drive_enable_ok must be set. If the start_homing input is reset during homing, the homing run is aborted without an error.

- **start_pos:**

A rising edge signals that a new motion task has to be accepted. A falling edge has no consequence.

During homing, this input has no effect.

- **abs_rel:**

If this input is set with a rising edge at the start_pos input, the positioning run is executed relatively to the current target position. If this input is not set with a rising edge at start_pos, an absolute positioning run is executed.

- **change_immediatly:**

If this input is set with a rising edge at the start_pos input, a running positioning is aborted immediately and replaced with a new motion task. If this input is not set with a rising edge at start_pos, the new motion task is added to the end of the running positioning.

- **intermediate_stop**

If this input is not set, a started positioning run is completed. If the input is set during a running positioning run, the drive is stopped and remains in position control mode. The current positioning run is **not** terminated. It will be continued when the intermediate_stop input is reset.

During homing, this input has no effect.

- **hold:**

If this input is set, the current positioning run is stopped. The system is slowed down with the deceleration valid for this positioning run. After the process has been completed, the pos_ok output is not set. A reset of the input has no effect.

During homing, this input has not effect.

- **jog_pos:**

If the input is set, the drive accelerates with the acceleration value set in position set „Tipp & Teach" until it reaches the speed also parameterized in this position set.

If there is a falling edge at this input, the drive slows down to standstill with the deceleration set in position set „Tipp & Teach".

During homing, this input has no effect.

- **jog_neg:**

If the input is set, the drive accelerates with the acceleration set in position set „Tipp & Teach" until it reaches the speed also parameterized in this position set.

If there is a falling edge at this input, the drive slows down to standstill with the deceleration set in position set „Tipp & Teach".

During homing, this input has no effect.

- **fault_reset:**

If there is a rising edge at this input, pending fault messages are acknowledged.

- **Outputs:**

  - **drive_enable_ok:**

  The controller enabling of the servo positioning controller is active.

  - **home_valid:**

  This output is set, if there is a valid home position. The output is not set during a running homing run. It is not set or reset until after a homing run has been completed successfully.

  - **pos_ok:**

  This output is set, when the current position is in the target window after the positioning run has been completed.

  - **velo_zero:**

  This output is set, if the actual velocity is zero in range of the message window.

  The message window is parametrized in the DUET_FL ServoCommander ™ under
  Parameters - Messages – Motor speed messages – message window.

  - **fault:**

  If this output is set, there is a fault. The controller enabling is cancelled.
  The output is reset after the fault has been acknowledged.

Please note the timing shown in the diagram when using the function blocks.

EN

EN0

drive_enable

drive_enable_ok

start_pos
bzw.
start_homing
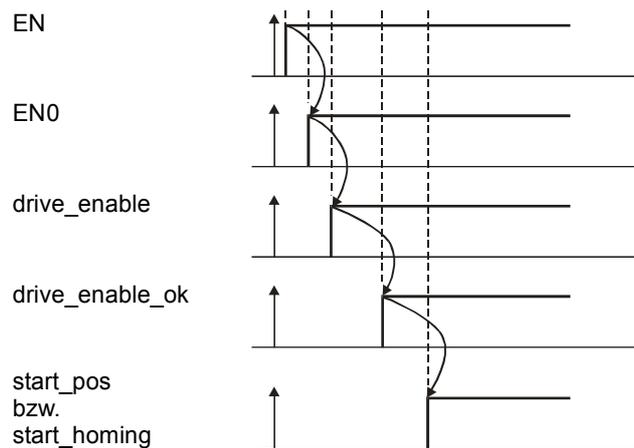
13.2.2.2   FB_velocity (FB 43 speed control)

```
                    "FB_velocity"
              ┌────────────────────────┐
      ... ──┤EN                        │
            │                          │
            │DB_nr_vel                 │
      ... ──┤ocity                     │
            │                          │
            │DB_nr_act    drive_ena    │
      ... ──┤ual_value    ble_ok       ├──...
            │                          │
            │drive_ena    velo_zero    ├──...
      ... ──┤ble                       │
            │             velo_reac    │
      ... ──┤hold         hed          ├──...
            │                          │
      ... ──┤jog_pos      velo_exce    │
            │             eded         ├──...
      ... ──┤jog_neg                   │
            │                fault     ├──...
            │fault_res                 │
      ... ──┤et                   ENO  ├──
            └────────────────────────┘
```

- **Parameters:**

  - **DB_nr_velocity:**

    The number of the data block containing the data for speed control mode (INT)

  - **DB_nr_actual_value:**

    The number of the data block containing the actual value data (INT).

- **Inputs:**

  - **drive_enable:**

    Activation of the controller enabling in speed control mode. The speed setpoint takes effect depending on the other inputs of the function block.

    - **hold:**

    If this input is set, the speed setpoint is blocked. The drive slows down to standstill as quickly as possible. When the input is reset, the motor accelerates along the paramerized setpoint ramp to reach the adjusted speed setpoint.

    - **jog_pos:**

    If this input is set, the drive accelerates with the set acceleration of the setpoint ramp until it reaches the speed parameterized in position set „Tipp & Teach".
    If there is a falling edge at this input, the drives slows down to standstill with the set deceleration of the setpoint ramp.

    - **jog_neg:**

    If this input is set, the drive accelerates with the set acceleration of the setpoint ramp until it reaches the speed parameterized in position set „Tipp & Teach".
    If there is a falling edge at this input, the drives slows down to standstill with the adjusted deceleration of the setpoint ramp.

- **fault_reset:**

If there is a rising edge at this input, pending fault messages are acknowledged.

- **Outputs:**

  - **drive_enable_ok:**

  The controller enabling of the servo positioning controller is active.

  - **velo_zero:**

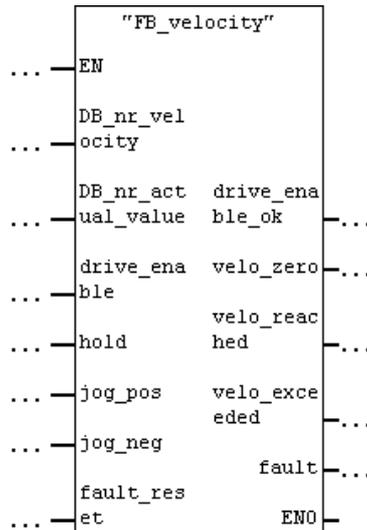 This output is set, if the actual velocity is zero in range of the message window.

  The message window is parametrized in the DUET_FL ServoCommander ™ under
  Parameters - Messages – Motor speed messages – message window.

  - **velo_reached:**
  When this output is set, the actual velocity is in the parameterized tolerance window of the target speed (declared speed).

  - **velo_exceeded:**
  If this output is set, the actual speed is greater than the free reference speed.

  - **fault:**
  If this output is set, there is a fault. The controller enabling is cancelled.
  The output is reset after the fault has been acknowledged.

13.2.3 Integration of FBs and DBs

As shown in the overview, the function and data blocks developed for the DUET_FL 48/10 FB servo positioning controllers can be downloaded free of charge.

Information

The function and data blocks can be downloaded under **www.Motor Power Company.de**

The blocks are packaged into two example projects in the file **FB_DB_DUET_FL FB_xpx.zip**. **xpx** stands for the current version number. The file can be opened using commercially available programs, such as, for example, WINZIP. Example projects:

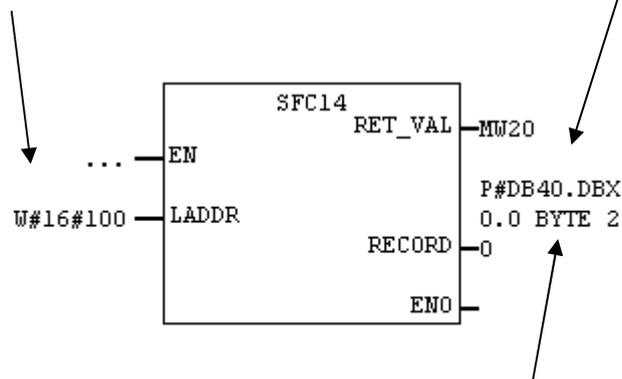| Operating mode	Example project
Positioning	DUET_FL_FB_POS.zip
Speed control	DUET_FL_FB_VEL.zip

The unpacked example projects can be de-archived under STEP7. The relevant FBs, DBS and SFCs can be copied from these de-archived example objects.

To ensure consistent data exchange between the PROFIBUS master and the PROFIBUS slave, the system functions SFC14 (consistent reading) and SFC15 (consistent writing) must be used. The following parameters have to be used for the blocks:

Reading data using SFC14:

Input data area
256dez = 100hex

Data block number into which
the data of the slave are written

```
                        SFC14
                     RET_VAL  —MW20
        ... ┤EN
                                  P#DB40.DBX
        W#16#100 ┤LADDR           0.0 BYTE 2
                     RECORD ┤0

                     ENO ┤
```

Initial address within the DB (0.0) and number of bytes
received (20 bytes)

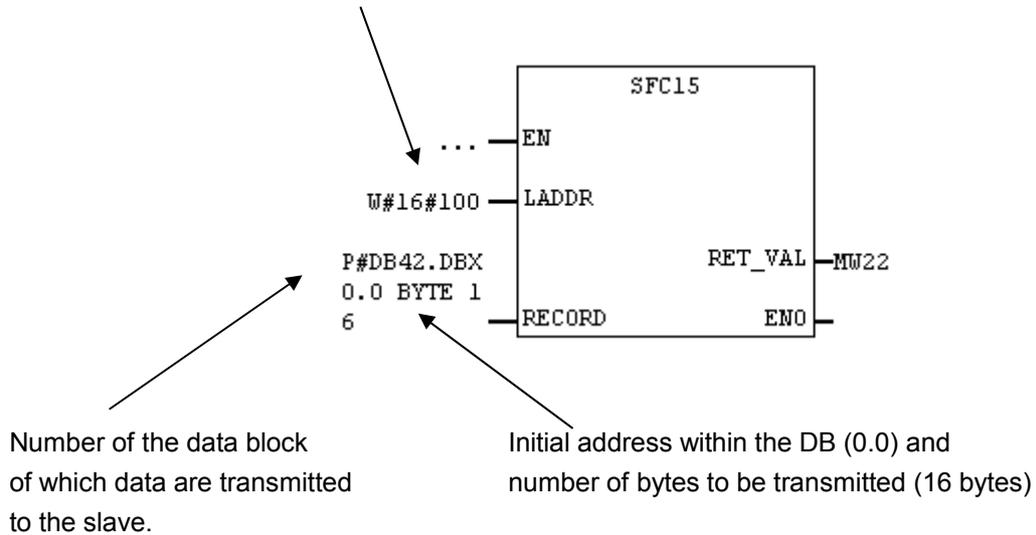| Parameter	Declaration	Data type	Storage area	Description
LADDR	INPUT	WORD	E, A, M, D, L, const.	Projected initial address of the E-area of the module which has to be read.
RET_VAL	OUTPUT	INT	E, A, M, D, L	If a fault occurs while the function is processed, the return value contains a fault code.
RECORD	OUTPUT	ANY	E, A, M, D, L	Target area for the useful data read. This area has to be as long as has been projected for the selected module with STEP 7. Only the data type BYTE is admissible.

In both example projects (positioning example project and speed control example project), the same actual value data are returned. As a consequence, the response telegram is configured in an identical manner in both example projects.

Writing data using SFC15:

Depending on the operating mode (positioning or speed control), different data are transmitted to the PROFIBUS slave. This leads to different telegram lengths affecting the parameterisation of SFC15.
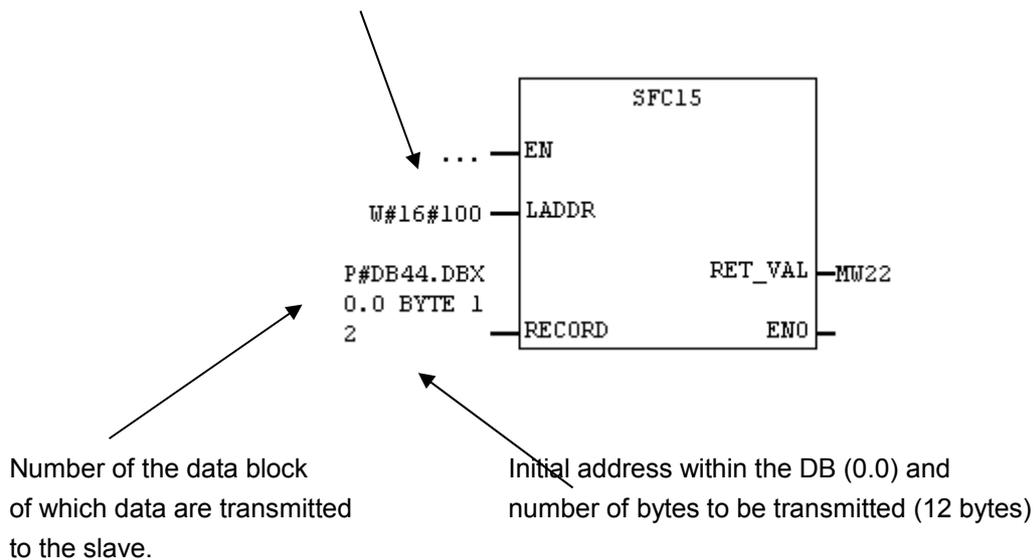
Writing data for the positioning mode:

Output data area 256dez = 100hex

```
                          ┌──────────────────┐
                          │      SFC15        │
          ...  ──── EN    │                  │
                          │                  │
   W#16#100  ──── LADDR   │                  │
                          │         RET_VAL  ├── MW22
  P#DB42.DBX             │                  │
  0.0 BYTE 1             │                  │
  6         ──── RECORD   │          ENO     ├──
                          └──────────────────┘
```

Number of the data block   Initial address within the DB (0.0) and
of which data are transmitted   number of bytes to be transmitted (16 bytes)
to the slave.

Writing data for the speed control mode:

Output data area 256dez = 100hex

```
                          ┌──────────────────┐
                          │      SFC15        │
          ...  ──── EN    │                  │
                          │                  │
   W#16#100  ──── LADDR   │                  │
                          │         RET_VAL  ├── MW22
  P#DB44.DBX             │                  │
  0.0 BYTE 1             │                  │
  2         ──── RECORD   │          ENO     ├──
                          └──────────────────┘
```

Number of the data block   Initial address within the DB (0.0) and
of which data are transmitted   number of bytes to be transmitted (12 bytes)
to the slave.

Parameter	Declaration	Data type	Storage area	Description
LADDR	INPUT	WORD	E, A, M, D, L, const.	Projected initial address of the A-area of the module which has to be written to.
RECORD	INPUT	ANY	E, A, M, D, L	Source area of the useful data to be written. It has to be as long as has been projected for the selected module with STEP 7. Only the data type BYTE is admissible.
RET_VAL	OUTPUT	INT	E, A, M, D, L	If a fault occurs while the function is processed, the return value contains a fault code.

13.2.4 PROFIBUS connection of DUET_FL 48/10 FB servo positioning controller

Several steps have to be performed to set up a functional PROFIBUS connection. Some settings should or have to be made before the PROFIBUS communication can be activated.

The transmission of data using the DP-V0 service requires a definition of the number of data to be transmitted and of the meaning of these data, both at the master and at the slave end. If the example projects described above are used, the master and the slave have to be configured accordingly.

When the example projects are loaded, the data blocks are already structured as required. The telegrams have to be structured as required by the example projects using the DUET_FL ServoCommander™ parameterisation program. Information concerning the use of the telegram editor and further information on the parameters can be found in the previous chapters of the PROFIBUS product manual.

13.2.4.1   Reception telegram of the speed control example project

In this case, reception telegram 1 at the servo positioning controller end has to be configured. The following screenshot shows the necessary parameterisation of the reception telegram for the example project. An additional diagnostic information is displayed above the button „Change entry" if a communication could have been established between Master and Slave. The really configured length of the telegram from Master to Slave is displayed.

The following table describes the telegram structure:

Address	Content (parameter number)	Description
0	Identifier (= 0xE1)	Fixed identifier
1	8-bit placeholder (PNU 2010 0)	Free
2	Control word 1 (PNU 967 0)	Control word for device control, has to be under this address
4	Target velocity (PNU 1010 0)	Speed setpoint, indication with the physical unit set for PROFIBUS
8	Acceleration (PNU 1011 2)	Combination of the values for acceleration and deceleration, indication with the physical unit set for PROFIBUS

The total length of this telegram is 12 bytes. When the slave is integrated into the hardware configuration of the master, the module:

6 Words Output

has to be selected for the output data and connected to one of the ports.

13.2.4.2   Reception telegram of the positioning example project

In this case, reception telegram 0 at the servo positioning controller end has to be configured. The following screenshot shows the necessary parameterisation of the reception telegram for the example project. An additional diagnostic information is displayed above the button „Change entry" if a communication could have been established between Master and Slave. The really configured length of the telegram from Master to Slave is displayed.

The following table describes the telegram structure:

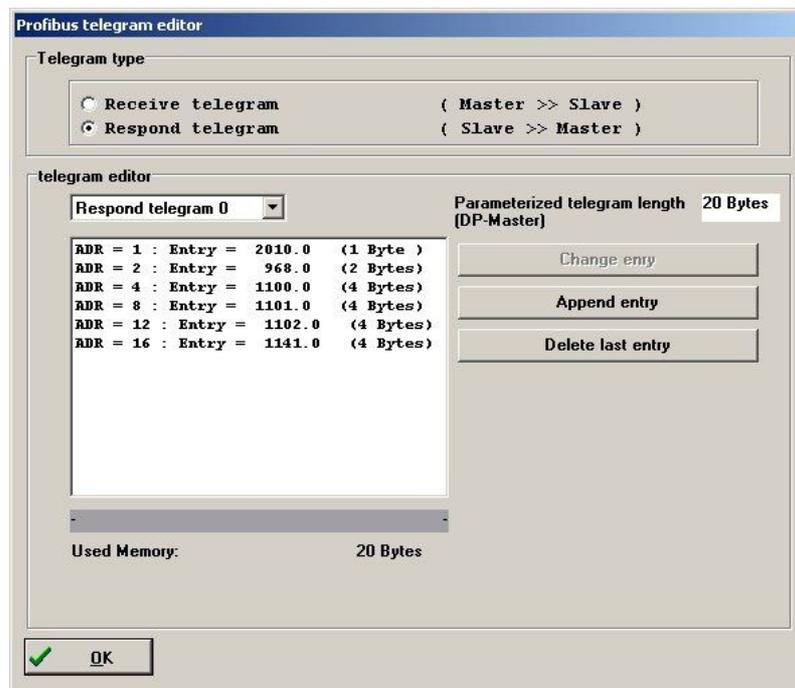| Address	Content (parameter number)	Description
0	Identifier (= 0xE0)	Fixed identifier
1	8-bit placeholder (PNU 2010 0)	Free
2	Control word 1 (PNU 967 0)	Control word for device control, has to be under this address
4	Target position (PNU 1001 0)	Target position, indication with the physical unit set for PROFIBUS
8	Profile velocity (PNU 1001 1)	Profile velocity during positioning, indication with the physical speed unit set for PROFIBUS
12	Accelerations (PNU 1001 5)	Combination of the values for acceleration and deceleration, indication with the physical unit set for PROFIBUS

The total length of this telegram is 16 bytes. When the slave is integrated into the hardware configuration of the master, the module:

8 Words Output

has to be selected for the output data and connected to one of the ports.

13.2.4.3   Response telegram for the example projects

In both example projects, the same actual value data are transmitted from the slave to the master. Thus, the same response telegram 0 has to be configured for both reception telegrams (0 and 1) at the servo positioning controller end. The following screenshot shows the necessary parameterisation for the example project. An additional diagnostic information is displayed above the button „Change entry" if a communication could have been established between Master and Slave. The really configured length of the telegram from Master to Slave is displayed.

The following table describes the telegram structure:

| Address	Content (parameter number)	Description
0	Identifier (= 0xF0)	Fixed identifier
1	Operating mode (PNU 1500 0)	Current operating mode of the servo positioning controller
2	Status word 1 (PNU 968 0)	Control word for device control, has to be under this address
4	Position Actual Value (PNU 1100 0)	Actual position, indication with the physical position unit set for PROFIBUS
8	Velocity Actual Value (PNU 1101 0)	Actual speed value, indication with the physical speed unit set for PROFIBUS
12	Current actual value (PNU 1102 0)	Actual value of the current, indicated per thousand referring to the nominal motor current
16	Digital inputs (PNU 1141 0)	Current status of the digital inputs, see for the meaning of the bits in the detailed description of the PNU.

The total length of this telegram is 20 bytes. When the slave is integrated into the hardware configuration of the master, the module:

10 Words Output

has to be selected for the input data and connected to one of the ports.

13.2.5 Creating an S7 program

First start the STEP 7 software. After the start of the SIMATIC Manager, the STEP7 Wizard is opened. Follow the instructions of the STEP 7 Wizard. The STEP 7 Wizard leads you step by step through the creation of an S7 project.
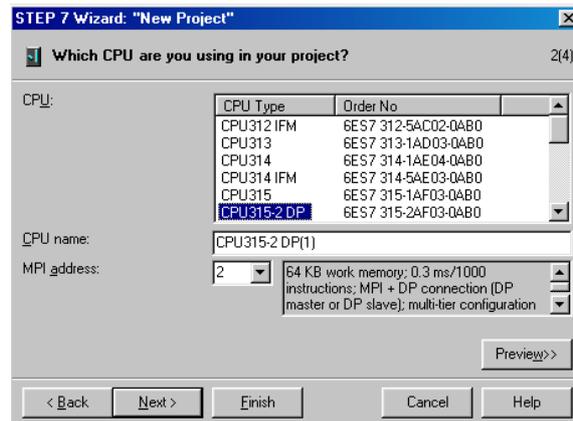
Then select the organization module **OB1**. **OB1** is located at the top program level and organizes all the other modules.

Additional modules can be added later.

After that, select the preferred programming language. This language can be converted into other programming languages later.

13.2.6 Integrating the GSD file

As a next step, the hardware of the PLC system used must be configured in the project created. To do so, select **SIMATIC 300** in the left pane. Then double-click on **Hardware** in the right pane.

Close the station by clicking on **Station** -> **Close**, without quitting the hardware configuration program.
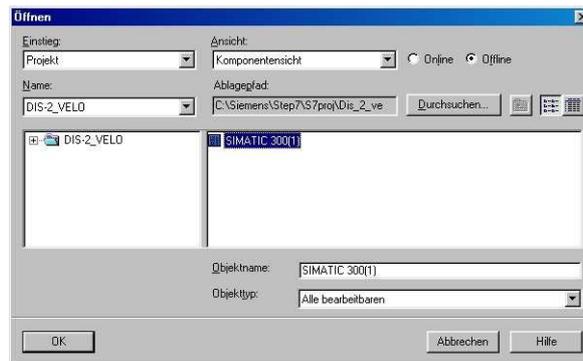
The command **Options->Install new GSD...** adds the GSD file MME0A38.gsd, which is required for adding the DUET_FL 48/10 FB to the hardware catalog.


13.2.7 Hardware configuration

The S7 project must then be opened using the command **Station** -> **Open...** .

Select the project name in the **Name** field of the **Open** window. Then select **SIMATIC 300(1)** in the right window pane. Then click on the **OK** button to open the hardware configuration of your project.

The following screenshot shows the hardware catalogue from which the hardware components can be selected. If the hardware catalogue is not shown, it can be called up by clicking on **View** -> **Catalog**.
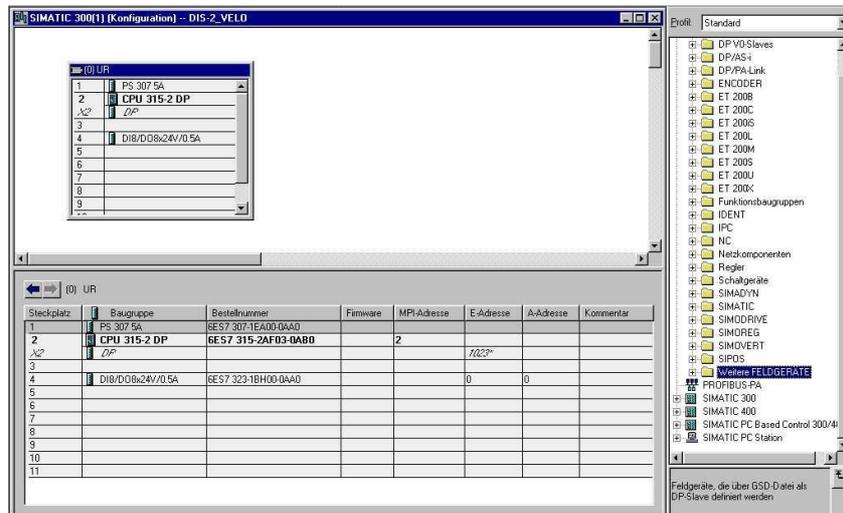
Use the mouse to select the desired hardware components from the **Catalog** and drag them into the station window.

| Slot	Module	...	Order number	Firmware	MPI address	I address	Q address
1	PS307 5A		6ES7 307-1EA00-0AA0				
2	CPU315-2 DP		6ES7 315-2AF03-0AB0		2		
X2	DP-Master					1023*	
3							
4	DI8/DO8x24V/0.5A		6ES7 323-1BH00-0AA0			0	0
5							

> **Information**
>
> The order numbers in the project must match the order numbers of the hardware (shown on the front). Port 3 is not used as the project does not use a controller board.

13.2.8 Integrating the servo positioning controller

The servo positioning controller is integrated by selecting the line **X2 DP-Master** in the station window. Then add the Profibus with the help of the command **Insert** -> **Master System**.

Then add the desired module to the Profibus using drag&drop from the directory **PROFIBUS-DP** -> **Additional Field Devices** -> **Closed-loop controllers-> DUET_FL 48/10 FB** of the hardware catalogue.
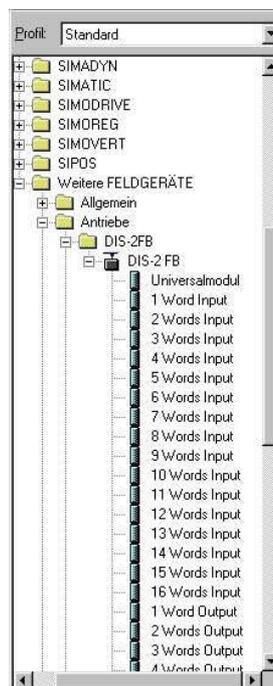

The telegram length has to be taken into consideration when selecting the modules. This means:

❖ Select the module **8 Words Output** for the positioning mode setpoint telegram and the module **6 Words Output** for the speed control setpoint telegram.

❖ Select the module **10 Words Input** for the actual value telegram.

It is also possible to use both function blocks in one project. In this case, the module **8 Words Output** has to be used.

The Profibus address of the servo positioning controller has to be set in the **Properties** window. The address has to be the same as the address previously set with the DUET_FL ServoCommander™ program. The servo positioning controller is now integrated.

The hardware configuration should now look like that:
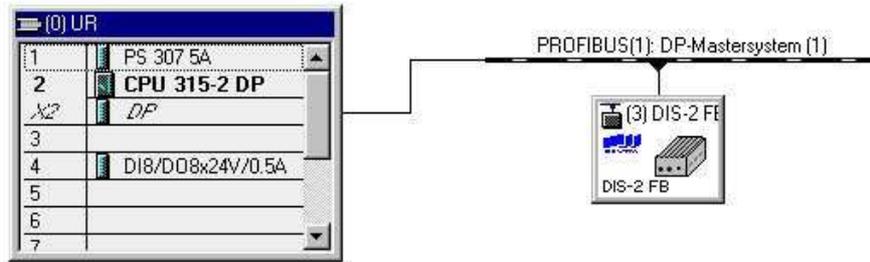
The S7 project is now prepared and programming can be started.

13.2.9 Overview of function and data blocks:

Overview of positioning mode example project

Overview of speed control example project

Actual values

DB40 actual_value   Actual values of the servo positioning controller (for both example projects)

DB40 -- DIS-2_POS\SIMATIC 300(1)\CPU 315-2 DP

Adresse	Name	Typ	Anfangswert	Aktualwert	Kommentar
0.0	Telegrammkennung	BYTE	B#16#0	B#16#0	
1.0	Betriebsart	BYTE	B#16#0	B#16#0	herstellerspezifisch
2.0	PROFIDRIVE_Statusword	WORD	W#16#0	W#16#0	
4.0	Istposition	DINT	L#0	L#0	übertragener Parameter in default-Parametrierung
8.0	Istgeschwindigkeit	DINT	L#0	L#0	übertragener Parameter in default-Parametrierung
12.0	Wirkstromistwert	DINT	L#0	L#0	übertragener Parameter in default-Parametrierung
16.0	digitale_Eingaenge	DWORD	DW#16#0	DW#16#0	übertragener Parameter in default-Parametrierung

Positioning

FB41 FB_position   Function block for the positioning mode

DB41 Instance DB for FB41   The data block of internal variables belonging to the function block

DB42 DB_position   Positioning data

DB42 -- DIS-2_POS\SIMATIC 300(1)\CPU 315-2 DP

Adresse	Name	Typ	Anfangswert	Aktualwert	Kommentar
0.0	Telegrammkennung	BYTE	B#16#0	B#16#E0	
1.0	frei	BYTE	B#16#0	B#16#0	vorläufige Platzhaltervariable
2.0	PROFIDRIVE_Controlword	WORD	W#16#0	W#16#0	
4.0	Zielposition	DINT	L#0	L#5000	zu übertragender Parameter in default-Parametrierung
8.0	Fahrgeschwindigkeit	DINT	L#0	L#200	zu übertragender Parameter in default-Parametrierung
12.0	Beschleunigung	DINT	L#0	L#100000	zu übertragender Parameter in default-Parametrierung

Speed control

FB43 FB_velocity   Function block for speed control mode

DB43 Instance DB for FB43   Data block of internal variables belonging to the function block

DB44 DB_velocity   Data for speed control mode

DB44 -- DIS-2_VELO\SIMATIC 300(1)\CPU 315-2 DP

Adresse	Name	Typ	Anfangswert	Aktualwert	Kommentar
0.0	Telegrammkennung	BYTE	B#16#0	B#16#E1	
1.0	frei	BYTE	B#16#0	B#16#0	vorläufige Platzhaltervariable
2.0	PROFIDRIVE_Controlword	WORD	W#16#0	W#16#0	
4.0	Geschwindigkeitssollwert	DINT	L#500	L#500	zu übertragender Parameter in default-Parametrierung
8.0	Beschleunigung	DINT	L#100000	L#50000	zu übertragender Parameter in default-Parametrierung