SIEMENS

SIMATIC S5

IP 266
Positioning Module

Manual

SIMATIC S5

IP 266
Positioning Module

Manual

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for 6ES5 266-5AA21

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Preface

The IP 266 is a powerful intelligent I/O "positioning" module that was developed specially for installation in the S5-100U programmable controller. The IP 266 makes it possible to operate servomotors via power electronics equipment. The IP 266 can be used in conjunction with the following CPUs:

- CPU 100 (6ES5 100-8MA02 only)
- CPU 102 (without restriction)
- CPU 103 (without restriction)

The IP 266 provides numerous functions for both open-loop and closed-loop positioning. These functions are described in detail in the section entitled Modes.
The IP 266 provides modes for

- positioning
- coordinate shift and
- correction (compensation)

All modes can be used both separately and as a consequence of individual functions in machining programs.
The complex open-loop and closed-loop procedures which a standard programmable controller must perform in order to carry out a positioning task require a great deal of processor time.
The IP 266 can considerably reduce the amount of processor time needed because it takes over the entire positioning process.
Your control program can thus execute in parallel with the positioning procedure.
Sequences of motions involving several axes are made possible by the use of additional IP 266 modules.
Sequencing control can be implemented via the IP 266's digital inputs and outputs.

Because this module can be installed only in an S5-100U programmable controller, it has been assumed that the reader is well acquainted with the S5-100U product manual. The fundamentals of STEP 5 programming are not a topic of discussion in this manual.

Introduction

The information presented below is aimed at simplifying use of the manual.

Contents
The contents of the manual can be subdivided into topical categories:

- Hardware description
  Section 1 ("System Overview") and Section 2 ("Technical Description") provide information on the components of the positioning system and their integration in the S5-100U System.
  In addition to explanatory texts on connecting peripherals such as
  - screen-based programmers
  - encoders and
  - power electronics equipment

  you will also find detailed information on the connector pin assignments for the various interfaces and the locations of these interfaces on the IP 266 module.

- Installation guidelines
  All information relevant to system installation can be found in Section 3 ("Installation Guidelines"). This includes:
  - safety guidelines
  - shielding
  - switch installation
  - module installation and removal procedures

- Fundamentals of positioning
  Section 4 provides information on positioning options within the SIMATIC system, the principles of positioning and the IP 266's position control facilities. This section also defines terms such as setpoint, actual value and following error and the interrelation of acceleration, speed and path.

- Machine data, modes and traversing programs
  The data which the IP 266 needs in order to carry out the positioning process is discussed in detail in Section 5.
  This section also provides information on all modes, how they work, and the parameters they require.

- Fundamentals of COM 266
  This section provides information on how to
  - make a back-up copy of the COM 266 floppy
  - install COM 266 and
  - use COM 266.

  It also includes a full description of all COM 266 screen forms.

- Communication between the CPU and the IP 266
  Defined addressing message frames are used for data interchange over the bus interface. You must know how to use these message frames when you want to control the IP 266 via a STEP 5 program (see Section 7).

  Examples are presented in Section 9 ("STEP 5 Programming") to show you how to link and process these message frames in STEP 5 programs.

- Start-up
  This section describes the procedures for installing and starting the IP 266.
  The information presented in this section is based on that presented in Sections 5 and 6.

- STEP 5 programming (Section 9)
  This section uses examples to show you how to use the message frames discussed in Section 7.

- Troubleshooting
  This section tells you what to do when problems arise. It also provides a list of errors and information on how they can be rectified.

Training courses

Siemens offers an extensive range of training courses for the SIMATIC STEP 5 system.
For details, please contact your local Siemens branch office.

Reference literature

This manual deals primarily with the IP 266 positioning module. Other components of the SIMATIC S5 system are mentioned only briefly.

Detailed information on these components can be found in the following literature:

- **Programming Primer for the SIMATIC S5-100U**
  Practical exercises on the PG 615 programmer

  Siemens AG, Berlin and Munich, 1988

  Contents:
  - Configuration and installation of the S5-100U
  - Introduction to programming on the PG 615 programmer

  Order No.: ISBN 3-8009-1500-6

- **Programmable Controllers**
  Volume 1: Logic and Sequence Control Systems; from the
  Control Task to the Control Program

  Günter Wellenreuther, Dieter Zastrow
  Braunschweig 1987

  Contents:
  - Operating principles of a programmable controller
  - Theory of control technology using the STEP 5 programming language for the SIMATIC S5 programmable controllers

  Order No.: ISBN 3-528-04464-0

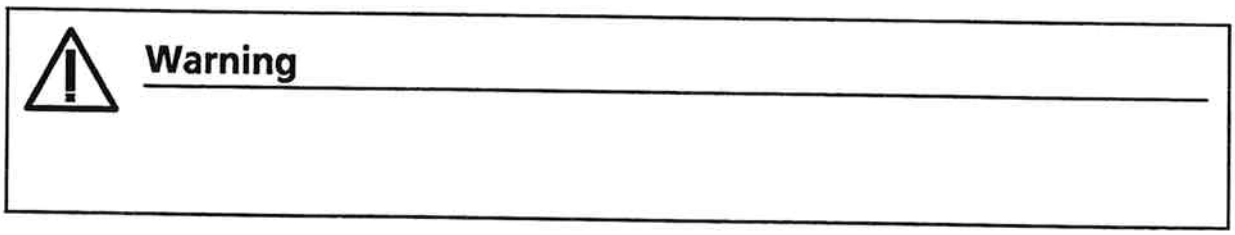
Conventions

This system manual is organized in menu form to make it easier for you to find information. This means the following:

- Each chapter is marked with printed tabs.
- At the front of the system manual is an overview page that lists the title of each chapter. Following this page, you will find a table of contents.
- At the beginning of each chapter is a table of contents for that chapter. Each chapter has three level headings that are numbered. The fourth level heading is not numbered but appears in **boldface type.**
- Pages, figures, and tables are numbered separately for each chapter. On the back of the table of contents for each chapter you will find a list of the figures and tables that appear in that chapter.

This system manual employs the following specific structuring devices:

- Specific terms have characteristic abbreviations (e. g., programmer is PG).
- Footnotes are marked with a raised number (e. g., "1") or a raised asterisk (" * "). You will find the corresponding explanations in the lower margin of the page or under a figure or table if the footnote appears in one of these.
- Lists are designated with bullets (● as in this particular listing) or with hyphens (-).
- Cross references are indicated as follows: (see section 7.3.2). There are no references to specific page numbers.
- Dimensions in drawings are indicated in millimeters and inches.
- Value ranges are indicated as follows: 17 to 21 or 17-21.
- Especially important information appears in framed boxes such as the following:



You will find definitions for the terms "Warning," "Danger," "Caution," and "Note" in the Safety-Related Guidelines for the User at the end of the introduction.

Safety-Related Guidelines for the User

This document provides the information required for the intended use of the particular product. The documentation is written for technically qualified personnel.

Qualified personnel as referred to in the safety guidelines in this document as well as on the product itself are defined as follows.

- System planning and design engineers who are familiar with the safety concepts of automation equipment.
- Operating personnel who have been trained to work with automation equipment and are conversant with the contents of the document in as far as it is connected with the actual operation of the plant.
- Commissioning and service personnel who are trained to repair such automation equipment and who are authorized to energize, de-energize, clear, ground, and tag circuits, equipment, and systems in accordance with established safety practice.

Danger Notices

The notices and guidelines that follow are intended to ensure personal safety, as well as protect the products and connected equipment against damage.

The safety notices and warnings for protection against loss of life (the users or service personnel) or for protection against damage to property are highlighted in this document by the terms and pictograms defined here. The terms used in this document and marked on the equipment itself have the following significance.

Danger

indicates that death, severe personal injury or substantial property damage will result if proper precautions are not taken.

Warning

indicates that death, severe personal injury or substantial property damage can result if proper precautions are not taken.

Caution

indicates that minor personal injury or property damage can result if proper precautions are not taken.

Note

contains important information about the product, its operation or a part of the document to which special attention is drawn.

Proper Usage

Warning

- The equipment/system or the system components may only be used for the applications described in the catalog or the technical description, and only in combination with the equipment, components, and devices of other manufacturers as far as this is recommended or permitted by Siemens.
- The product will function correctly and safely only if it is transported, stored, set up, and installed as intended, and operated and maintained with care.

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1 System Overview

The IP 266 intelligent I/O module adds yet another powerful positioning unit to the already wide range of S5-100U programmable controller modules. The IP 266 can position drives with exceptional accuracy. Once the programmable controller's CPU has started a job, it is no longer loaded by the IP 266. The positioning process now executes in parallel with your STEP 5 program.

The IP 266 counts the pulses generated by the incremental encoder. The count is then used to determine the current position.

Limit switches are connected to the module's digital inputs.

The IP 266 is equipped with the following:

- Serial bus interface to the 100U programmable controller
- Digital inputs and outputs
- Analog output for driving the power section over the standard ±10 V interface
- Status indicators for various operating states
- Interface for connecting an incremental position encoder to determine the current position
- Programmer port for connection of a screen-based programmer

The following example illustrates a number of typical applications for positioning modules. Particular emphasis is placed on the distinctions between the two types of axes (linear axis and rotary axis).

1.1 Application

In an assembly line, a gripper takes a workpiece from a conveyor belt and forwards it to an automatic assembling machine. The part is then returned to the conveyor belt. Figure 1-1 shows the schematic arrangement. Included in the illustration are three axes which are positioned e. g. via three IP 266 modules.

A linear axis can be used for raising and lowering the workpiece as well as for cross-machining from the conveyor belt to the assembling machine. The movement can be restricted to within defined limits. The conveyor belt can be initialized as continuous belt (rotary axis).

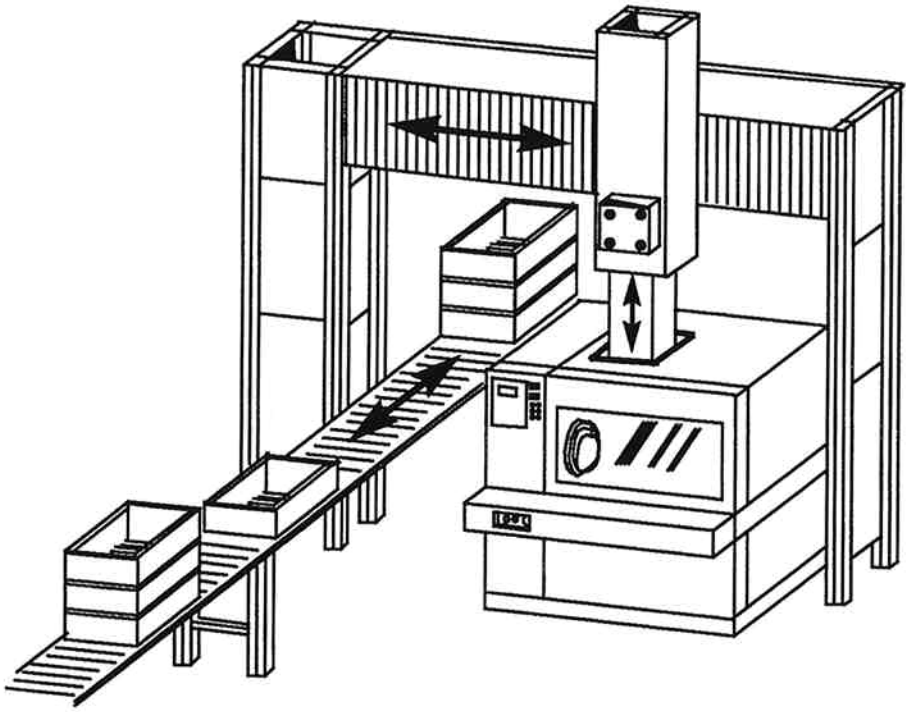


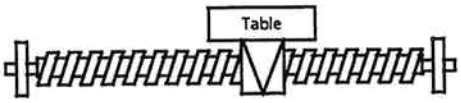
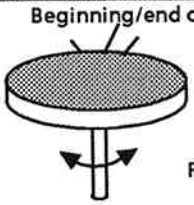
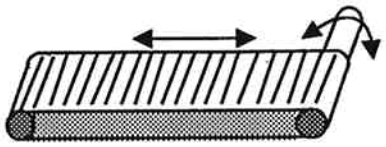
Fig. 1-1. Positioning with Three Axes

1.2 Axis Types

You can operate either
- rotary axes
  or
- linear axes on the IP 266. Initialization and operator servicing are dependent on the axis type.

Any differences are pointed out in the relevant chapters and sections.
This chapter contains a description of the individual types of axis.

Table 1-1. Axis Types

Linear Axis	Rotary Axis
	
	
can be initialized in [mm], [inch]	can be initialized in [deg], [mm], [inch]

The linear axis

A linear axis is an axis with a limited traversing range. The traversing range is restricted via

- programmable software limit switches (S_A/S_E)
- hardware limit switches (H_A/H_E)
- emergency limit switches (N_A/N_E)

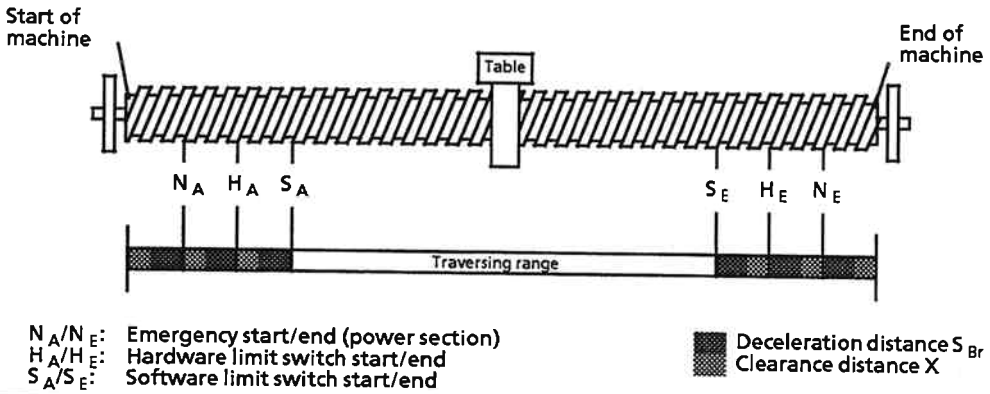


Fig. 1-2. Linear Axis with Range Limit Switches (not to scale)

The software limit switches do not go into force until the reference point has been determined (see Section 5.3.5).

The distance between the software limit switches and the hardware limit switches must be such that the drive can be decelerated at the specified deceleration rate before it reaches the hardware limit switches. In addition to deceleration distance S_{BR}, you must also maintain a clearance distance (X) between the end of the deceleration distance and the next limit switch.
The same applies to the distance between the hardware limit switches and the emergency limit switches.

Caution

Incorrect initialization of the limit switches may result in mechanical damage. Always make sure that you observe the clearance distance (X).

The emergency limit switches, which are routed directly to the power section, must also take the deceleration distance into account.

Caution

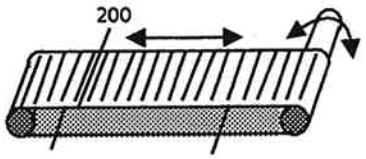
If you initialize a linear axis unintentionally as a rotary axis, there are no software limit switches. The drive can be stopped only over hardware limit switches.

The rotary axis
A rotary axis is an axis with an unlimited positioning range.
This may be e. g.

- a rotary table or
- a continuous belt

When a rotary axis is used, the start and the end of the positioning range are physically the same point on the axis.
The only effect the start of traversing range and end of traversing range parameters have is that of switching the actual value displays.

Example
A traversing range of 0 mm to 400 mm was specified in the machine data for a continuous conveyor belt. The value 0 mm and the value 400 mm both have the same physical location on the belt. When the value 400 mm is reached, the display switches to 0 mm.



The hardware limit switches are evaluated in the same way as for a linear axis, and provide extra protection when the positioning range is to be restricted to values less than one revolution.

1.3 Installing the IP 266 in a SIMATIC S5 System

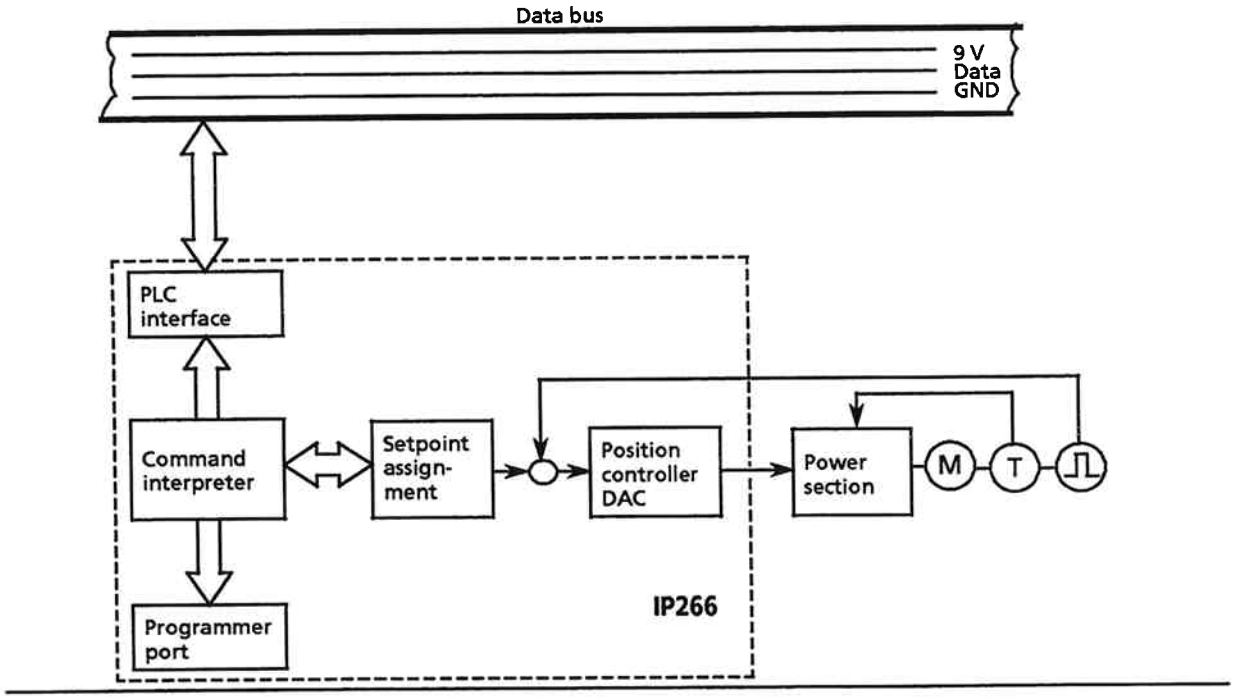


Figure 1-3. The IP 266 in a SIMATIC S5 System

The IP 266 can be plugged into a bus module slot for analog modules (slot 0 to 7). In addition to the wiring backplane, the IP 266 is also equipped with interfaces for connecting

- a programmer (PG 635, 675, 685, 730, 750)
- power electronics equipment with speed controller over the analog output
- 8 digital inputs/outputs for limit switches, reference point switches, ...
- an incremental position encoder (rotary or linear)

1.4 Operator Servicing Options (PLC and PG) and Their Priorities

The IP 266 can be controlled via a programmer (PG) or via the programmable controller's CPU. If job requests are issued to the IP 266 over both interfaces in the same firmware cycle, the request issued via the programmer has priority but the next PLC job request is serviced in the subsequent cycle. If this request differs from the PG request and the latter is still being serviced, the IP 266 aborts the job and flags an error.

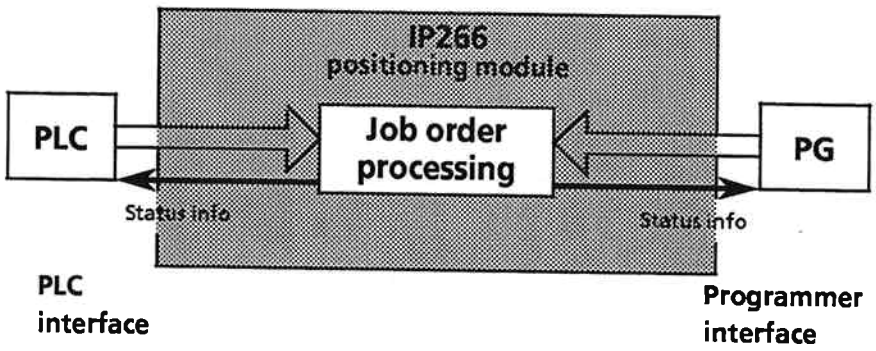


Figure 1-4. Principle of Job Order Processing

The IP 266 accepts two types of positioning requests:

- **Single job orders** (or requests) are forwarded to the IP 266 over the programmer port or the PLC interface.
  Single job orders are all modes with the exception of mode 8 (AUTO) and mode 9 (AUTO single block).

- **Machining programs**, i. e. a continuous sequence of single job orders, dwells, corrections and switching operations.
  The machining programs must be in the IP 266's memory. A machining program is started over an operator interface by specifying the operating mode and the program number.

Programmer port
The IP 266 can be serviced via a programmer connected over the programmer port. To do this, you must use the COM 266 software package, which provides menus and screen forms for initializing the IP 266. Screen forms are also used to specify the modes and display current actual values.

PLC interface
Input and output blocks are used for IP 266 control via the programmable controller's CPU and for forwarding return info from the IP 266 to the CPU. These blocks must be initialized in a STEP 5 program. Positions, mode numbers and the like can be entered using, for example, numerical setters. The values are forwarded in the process input and output images.

2 Technical Description of the IP 266

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2 Technical Description of the IP 266

The IP 266 is used for controlled positioning of a drive.
It is utilized primarily in applications involving

- auxiliary axes in metal-working machines
- paper and textile machines
- handling and loading equipment
- feed facilities for transfer and assembly lines

2.1 IP 266 Hardware Configuration

The IP 266 makes it possible for you to position a drive. Once a job has been started, no further demands pertaining to that job are placed on the programmable controller's CPU. The positioning process is self-sustained, and thus executes in parallel with your application program.

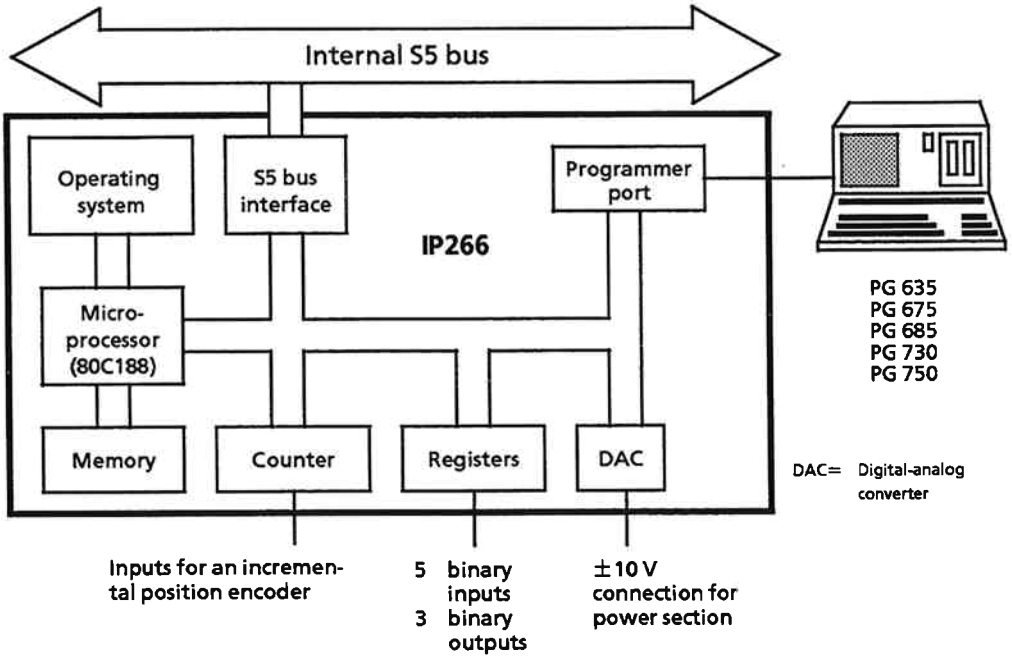


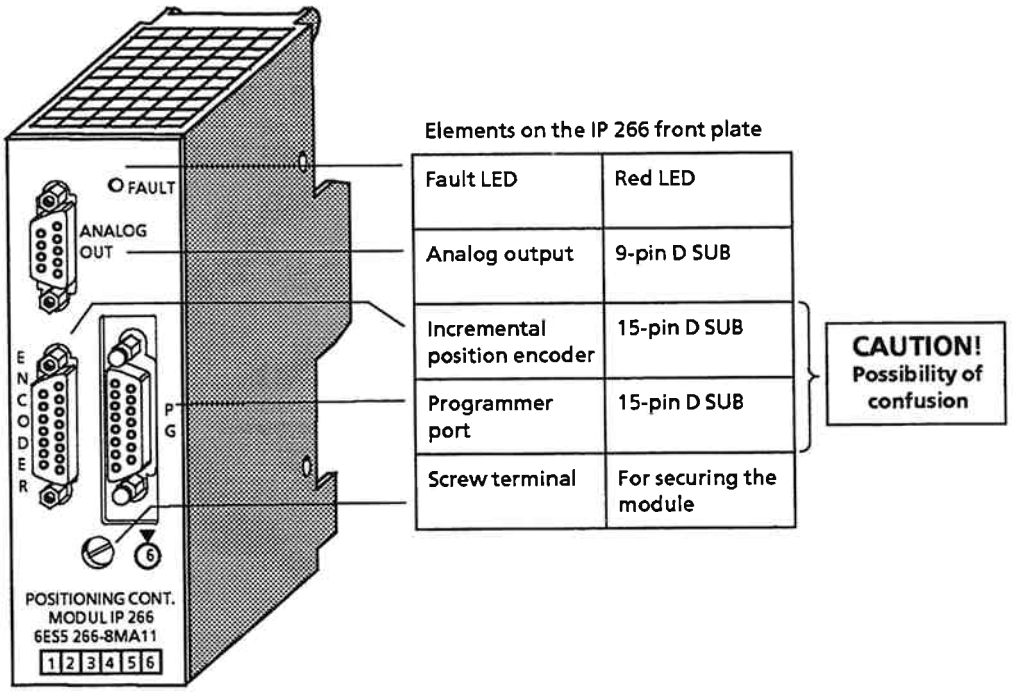
Figure 2-1. IP 266 Block Diagram with Interfaces

Figure 2-1 provides an overview of the most important module components.

Processor + operating system:	For coordinating all IP 266 tasks
Programmer interface:	For servicing the IP 266 via the COM 266 software • Start-up • Input/modification of machine data • Test mode: Starting traversing programs Starting single modes/jobs
S5 bus interface: (to the PLC's CPU)	For servicing the IP 266 via a STEP 5 program • Starting traversing programs • Starting single modes (jobs) • Reading single values from the IP 266 (actual value, distance to go, following error) • Acquiring and evaluating status info
Counter:	Input for an incremental position encoder. The counter counts the encoder pulses.
DAC:	Digital-analog converter: Analog output to the motor power section. The DAC converts the digital setpoint into an analog setpoint.
Registers:	Digital inputs and outputs

Locations of the interfaces on the IP 266

The IP 266 communicates with the I/Os over three interfaces located on its frontplate.



Elements on the IP 266 front plate

Fault LED	Red LED
Analog output	9-pin D SUB
Incremental position encoder	15-pin D SUB
Programmer port	15-pin D SUB
Screw terminal	For securing the module

CAUTION!
Possibility of confusion

Figure 2-2. Module Overview Diagram

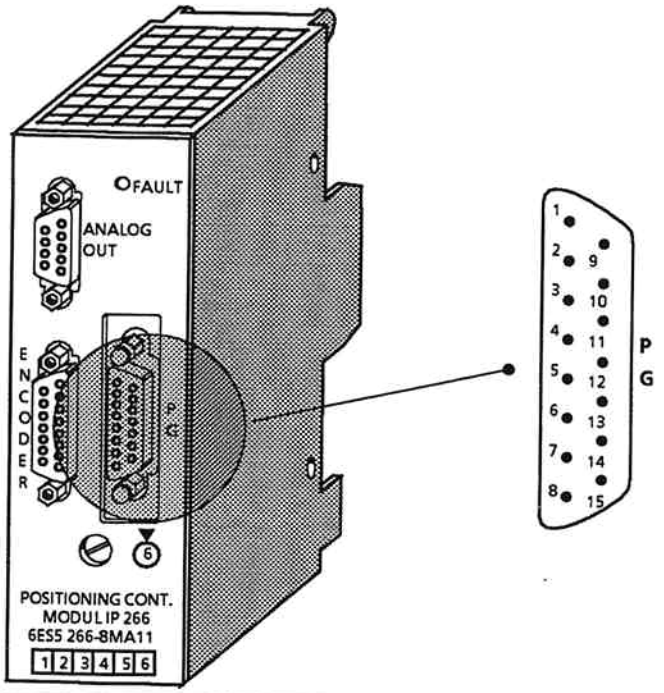
Note:

Be sure not to confuse the interface for the incremental position encoder with the programmer port. When you connect these I/Os, remember that the programmer port is the **rightmost** of the two 15-pin D SUB connectors.

In addition to the two 15-pin D SUB interfaces, the digital inputs and outputs must be connected to the module's terminal block.

2.2 Interface to the Programmer

You can connect a programmer to the IP 266 via the programmer port. The programmer port's connector pin assignments are compatible with those of the CPU module's programmer port. Use a standard interface cable, which is preset for 9600 bits/s, to connect a programmer.



Pin	Description
1	Shield
2	RxD_N
3	-
4	-
5	-
6	TxD_P
7	TxD_N
8	Shield
9	RxD_P
10 to 15	-

Figure 2-3. Programmer Interface Location and Pin Assignments

Caution

Like the encoder interface, the programmer port is a 15-pin interface, and it is therefore possible to confuse the one with the other. The programmer port is the one **at the right.** If you use the wrong interface, the module executes a RESET.

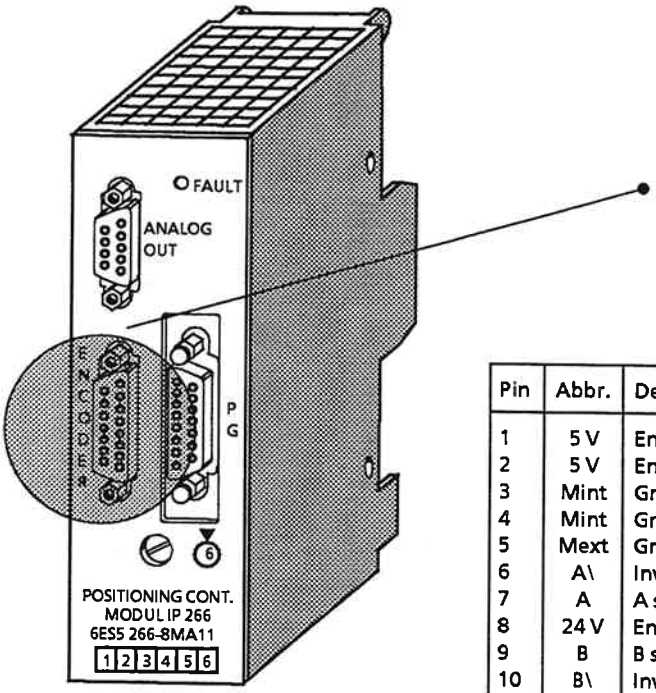
2.3 Interface to the Incremental Position Encoder

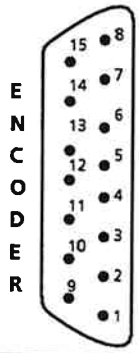
The IP 266 requires two signals in quadrature (signals A and B), i. e. displayed by 90 deg. with respect to each other, for position decoding and for ascertaining the direction of travel. These signals, as well as a reference signal (R), must be provided by the incremental position encoder.

Table 2.-1. Encoder Signals

Asymmetrical encoder (24 V)	Symmetrical encoder (5 V)
A*	A A\
B*	B B\
R*	R R\

You can connect either encoders with 5 V signals or encoders with 24 V signals.
The 5 V encoders must also provide the inverted signals A\, B\ and R\.
The 15-pin D SUB socket on the module's frontplate contains all supply and signal lines for both types of encoder.





Pin	Abbr.	Description	5V	24V
1	5 V	Encoder voltage	●	
2	5 V	Encoder voltage	●	
3	Mint	Ground (5 V)	●	
4	Mint	Ground (5 V)	●	
5	Mext	Ground (24 V)		●
6	A\	Inverted A signal	●	
7	A	A signal	●	
8	24 V	Encoder voltage		●
9	B	B signal	●	
10	B\	Inverted B signal	●	
11	R	Reference signal (zero mark)	●	
12	R\	Inverted reference signal	●	
13	A*	A signal (24V)		●
14	B*	B signal (24V)		●
15	R*	Reference signal (zero mark)		●

Figure 2-4. Position Encoder Interface Location and Pin Assignments

The choice between 5 V or 24 V encoder is made in the machine data when you initialize the IP 266.

In addition to incremental position encoders made by Siemens, you may also use non-Siemens encoders which conform to the following specifications:

- Method of measurement: Incremental
- Supply voltage: 5 V or 24 V
- Output signals:
  - Symmetrical encoders (5 V signals): A signal, B signal, R reference signal, A\ signal, B\ signal, R\ signal
  - Asymmetrical encoders (switching to P potential only): A* signal, B* signal
  - 24 V encoders: R* reference signal
- Max. operating frequency
  - 5 V encoder: 500 kHz for 30 m cable
  - 24 V encoder: 100 kHz for 25 m cable

We would recommend the following cable for connecting the IP 266 when using a Siemens encoder (6FC 9 320) for 5 V signals: Order No.: 6ES5 705-7 ... 1
The three dots in the Order No. stand for the three-digit length code. You will find a list of length codes in Catalog ST 52.1.

Connecting cable for Siemens 6 FB 9 320 position encoders

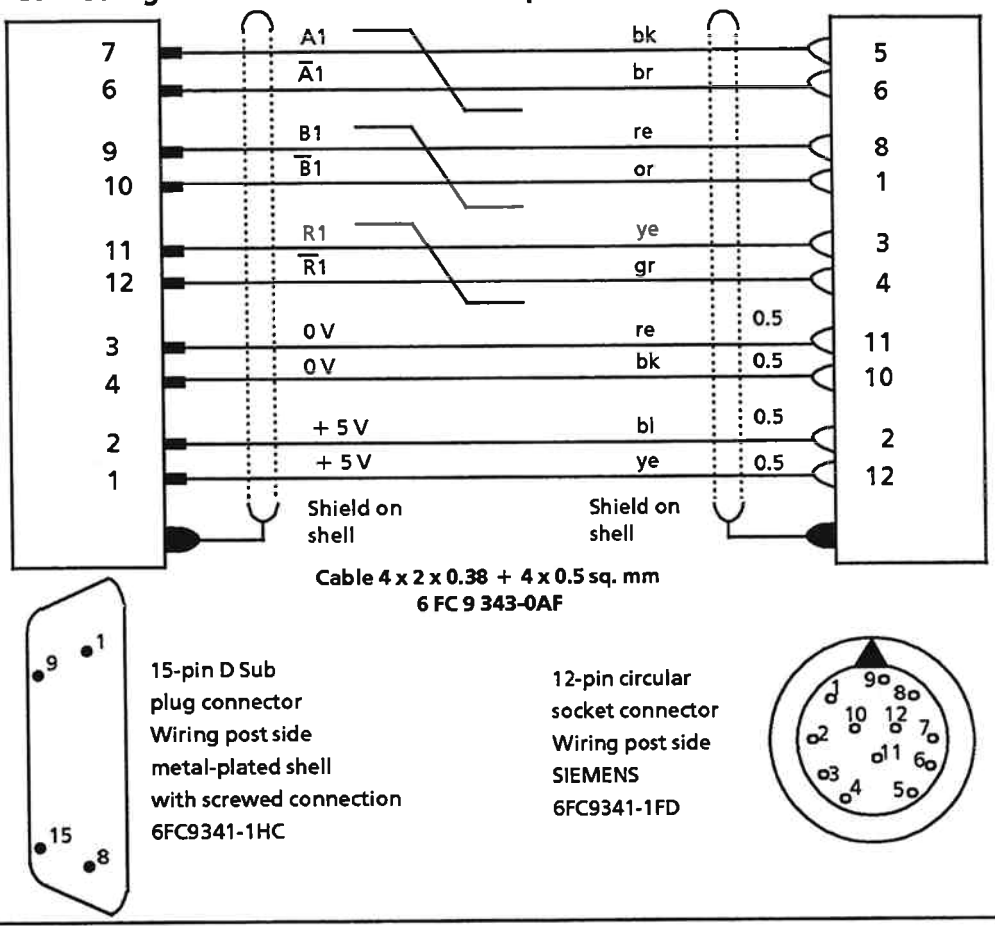
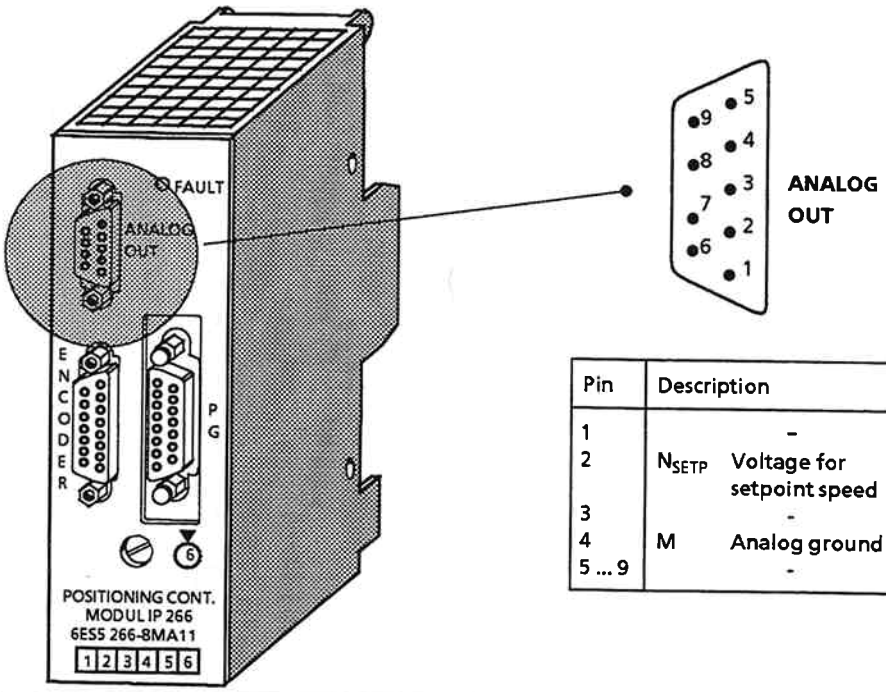


Figure 2-5. Connection Diagram for the Encoder Connecting Cable

2.4 Interface to the Motor Power Section

The IP 266 can output an analog setpoint speed of ±10 V over the 9-pin D SUB socket connector (ANALOG OUT). This voltage is used to control your motor power section.



Pin	Description	
1		-
2	N_{SETP}	Voltage for setpoint speed
3		-
4	M	Analog ground
5 ... 9		-

Figure 2-6. Analog Output Interface Location and Pin Assignments

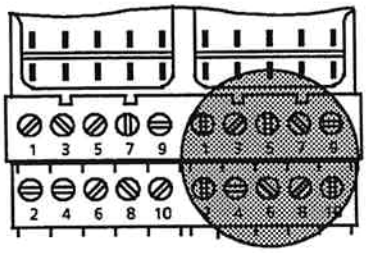
Siemens provides a prefabricated cable for connecting the analog output to the power section.
Order No.: Connecting cable 6ES5 705-8 ... 1
The three dots in the Order No. stand for the three-digit length code. You will find a list of length codes in Catalog ST 52.1.
The connecting cable is equipped with a 9-pin D SUB plug connector and has an open end for connection of the motor power section.

Caution

The connection information provided by the power equipment manufacturer and the general installation guidelines for SIMATIC components must be carefully observed to ensure fault-free operation. You may connect only power equipment with differential inputs for ±10 V, and the analog ground may not be connected to the external ground.

2.5 Interface for Digital Inputs and Outputs

The IP 266 is equipped with five digital inputs and three digital outputs which can be accessed over the bus module's terminal block.



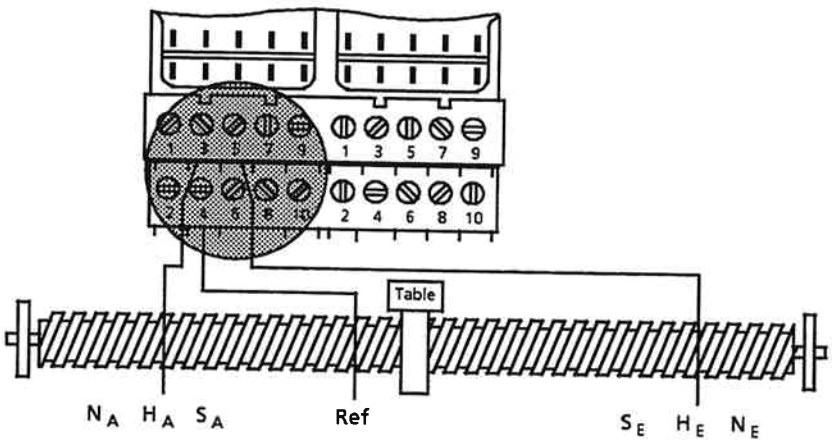
Pin	Terminal block assignments	DI	DO
1	L+ (24 V)		
2	L- External ground		
3	Hardware limit switch (start)	•	
4	Reference point switch	•	
5	Hardware limit switch (end)	•	
6	External STOP	•	
7	External START enable	•	
8	FUM (function signal - controller enable)		•
9	Position reached		•
10	Switching function M99 Enable for other modules		•

Figure 2-7. Terminal Block

> **Caution**
>
> Always connect reference potential L- (pin 2 on the terminal block) with the programmable controller's chassis ground to ensure fault-free module operation.

The polarity of the hardware limit switches and the "External STOP" can be specified in the machine data. When you set the machine data parameters, you can choose between "pos" (positive) polarity for NO contacts and "neg" (negative) polarity for NC contacts.

2.5.1 Hardware Limit Switches (Pins 3/5)



N_A/N_E: Emergency limit switch start/end (power section)
H_A/H_E: Hardware limit switch start/end
S_A/S_E: Software limit switch start/end
Ref: Reference point switch

Figure 2-8. Switch Connections on the Terminal Block

The hardware limit switches restrict the traversing range of the drive system to defined limits, and must be connected to terminal block pins 3 and 5.

2.5.2 Reference Point Switch (Pin 4)

The drive system is synchronized by reference point approach. The reference point switch must be connected to pin 4 on the terminal block (see Figure 2-8) and must lie between the two hardware limit switches. You must make sure that there is enough room between the reference point switch and the hardware switches for the drive to decelerate for reference point approach without reaching a hardware limit switch.

2.5.3 External Stop (Pin 6)

Machining can be stopped via the "External Stop" input. Travel is then stopped at the maximum specified deceleration rate and the IP 266 signals an "External stop". This signal also aborts the machining program (see Section 5.4). In Automatic mode, a dwell can also be cancelled.

Caution

An "External stop" in the "Follow-up" and "Controlled jog" control modes restarts the position controller.

The polarity of the "External Stop" can be specified in the machine data.

2.5.4 External Start Enable (Pin 7)

"External Start Enable" allows you to make the start of a positioning operation dependent on an external event, such as a signal from another IP 266 (for instance switching function M99, position reached).

A positioning operation cannot be started on the IP 266 unless this signal is present.

The signal also makes it possible to disable processing of a machining block or dwell. The machining program can be resumed at the point of interruption by activating the signal.

> **Note:**
>
> The "External Start Enable" signal does **not** interrupt a positioning operation or dwell that is currently in progress. Blocks belonging to G10 (see Section 5.4) are treated as two separate blocks.

The polarity of the "External Start Enable" signal is **not** programmable. The input must be wired as NO contact.

Table 2-2. Effect of "External Start" on Single Job Orders and Automatic Programs

Type of job order	IP 266 actions in the absence of a "External Start Enable" signal	Signals from the IP 266
Single job order	The positioning order is interpreted but not serviced.	Motor waiting for External Start Enable
	The positioning order is executed only when the "External Start Enable" signal is present.	
Automatic mode	Program is executed up to the first positioning order or first dwell.	Motor waiting for External Start Enable
	The order is interpreted and executed when the "External Start Enable" signal is present.	
	Subsequent orders can be disabled by cancelling this signal.	Motor waiting for External Start Enable

No other requests are permitted while the IP 266 is waiting for an "External Start Enable" signal. An attempt to issue another request is flagged with "Illegal request".

The Stop command resets the "Motor Waiting for External Start Enable" signal and the job is aborted.

2.5.5 Function Signal FUM (Pin 8)

The IP 266 outputs the FUM signal when it is ready for operation and has valid machine data at its disposal.

> **Caution**
>
> For reasons of safety, you may enable your power section only when the IP 266 has output the FUM signal. To do this, you must interlock the power section's Enable input with the FUM signal. If the power section has no Enable input, you must establish the interlock in some other way.

The FUM signal is removed immediately when invalid machine data is transferred to the IP 266.

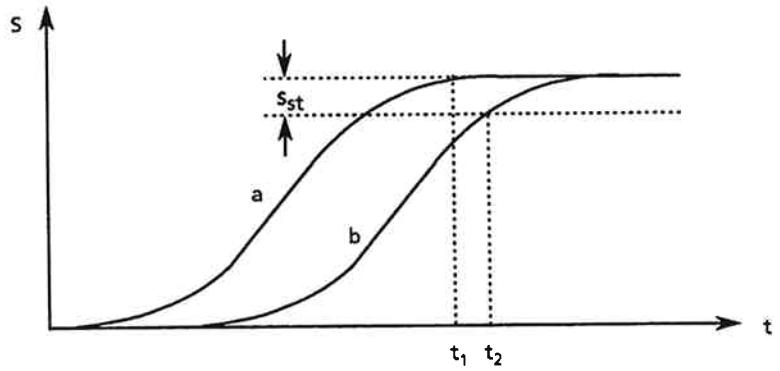
The FUM signal is reactivated when the error has been rectified and correct data forwarded to the IP.

2.5.6 Position Reached (Pin 9)

The "Position Reached" signal indicates error-free completion of a positioning operation with absolute or relative target specifications.

The signal is generated twice:
- As status bit in the input block (see Section 7)
- As signal on terminal block PIN 9

The following conditions must be fulfilled in order for this signal to be generated:
- The setpoint position must have reached the specified target coordinate (t_1).
- The actual position must lie within the tolerance limits for zero-speed monitoring (t_2).



a: Setpoint characteristic
b: Actual characteristic
s_{st}: Zero-speed monitoring
t_1: Setpoint reached
t_2: Actual value within zero-speed monitoring tolerance range

Figure 2-9. "Position Reached" Signal as a Function of Zero-Speed Monitoring

The axis status changes from "machining" to "finished" at the same moment the "Position Reached" signal is generated.

Note:

During execution of a machining program, the "Position Reached" signal is output after each block, the axis status signal "finished" only on termination of the machining program.

Table 2-3 shows the conditions under which the "Position Reached" signal is set.

Table 2-3. Switching Conditions for the "Position Reached" Signal

Actions	"Position Reached" is	
	set	not set
Absolute and relative target specifications: • Position setpoint must have reached the target coordinate and • Actual position lies within the tolerance range of zero-speed monitoring (beginning at time t_2 in Figure 2-9)	•	
Premature termination of a job with absolute or relative target specification ⇒ A residual distance remains until a new machining operation is started. A subsequent machining request with the distance to go shown positions the drive to the original target position		•
In machining programs, the termination of machining operations or dwells is indicated by the "Position Reached" signal.	•	
During execution of a machining program • when a dwell is aborted • when a traversing movement is aborted	•	•
In "1/2 jog" following a Stop command	•	
"Controlled jog" when the actual position no longer changes in a sampling interval	•	

Exceptions

A large non-compensated drift or a large load may result in the setpoint reaching the target position while the actual value remains outside zero-speed monitoring. If the maximum following error is not exceeded in the process, the IP 266 sets and starts a 5s watchdog timer. When no movement toward the target is detected within this time period, the IP 266 terminates the operation with "Target position not reached".

The "Position Reached" signal is not generated.

2.5.7 Switching Function M99 (Pin 10)

So-called M functions can be programmed in a machining program (see Section 5.4). These functions are returned to the PLC in the form of numerical values. One of these functions (M99) is also applied to an output; this signal can be used to execute program-controlled switching operations (for example, enabling another module).

2.5.8 Examples

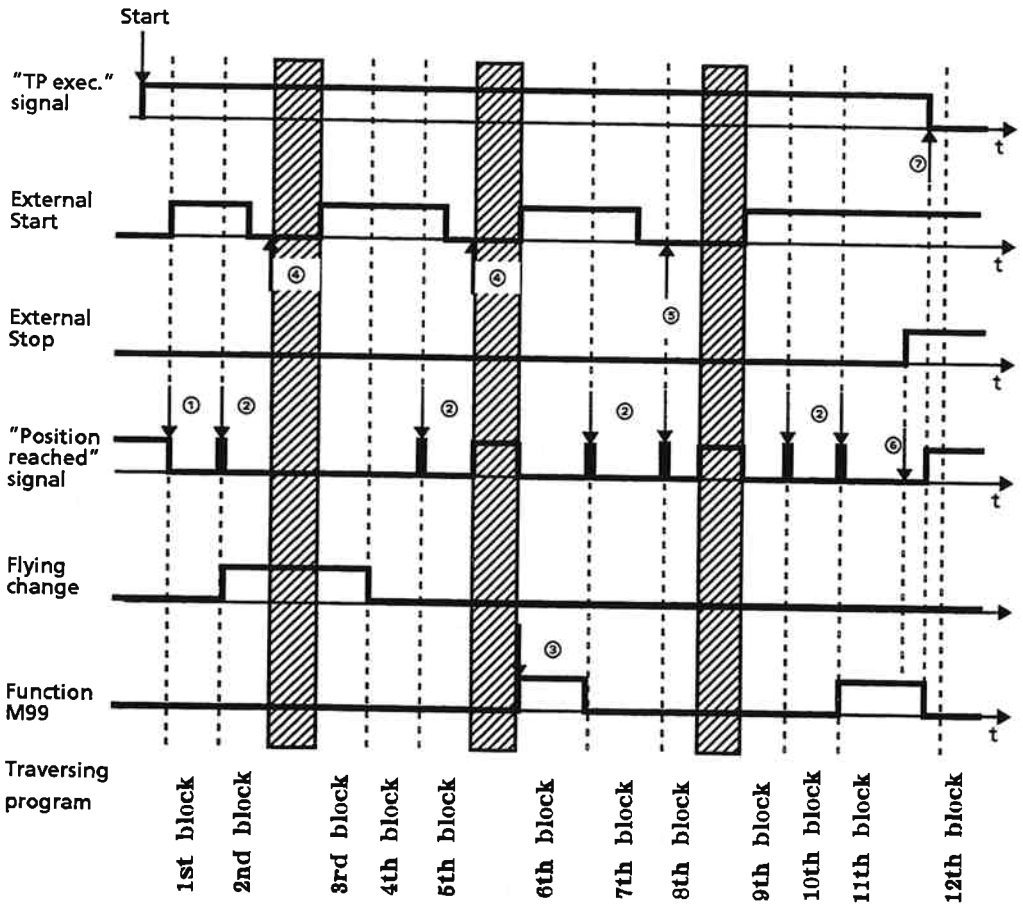
The following examples describe how to use the digital inputs and outputs for
- external start enable
- external stop
- position reached
- switching function

Example 1
This example examines the performance characteristics of the IP 266 when the "External Start Enable" signal is set to "0" prior to execution of each block.

A machining program containing machining operations, dwells, corrections and M functions is delayed prior to the start of each block by removal of the "External Start Enable" signal and then aborted with an "External Stop" signal.

Block	Job order	Machining program	Effect of the absence of the "External Start" signal
1	Traverse/rapid	N05 G00 X0 M05	Job is not executed
2	Traverse with G10	N10 **G10** X50 F100 M10	Job is not executed
3	Traverse with G10	N20 **G10** X200 F350 M20	Job is not executed
4	Traverse	N30 X250 F400 M00	Job is not executed
5	Dwell	N40 G04 F50 M40	Job is not executed
6	Traverse	N50 X300 F300 **M99**	Job is not executed
7	Dwell	N60 G04 F50 M60	Job is not executed
8	Correction/offset	N70 G54	***Job is executed***
9	Traverse	N80 G04 F50 M80	Job is not executed
10	Traverse	N90 X-2000 F2000 M90	Job is not executed
11	Dwell	N100 G04 F50 **M99**	Job is not executed
12	***End of program***	N110 M02	Job is executed

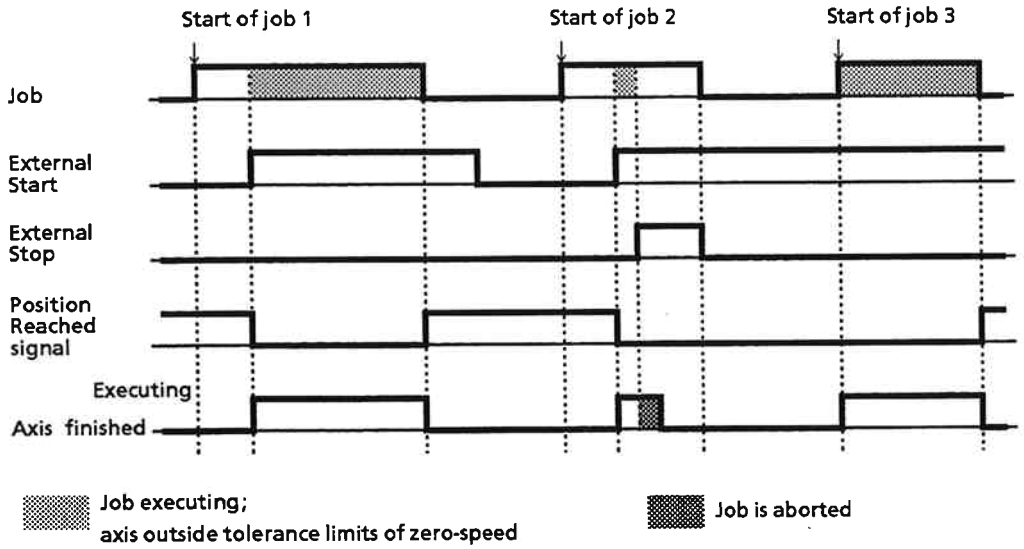
Example 2
The machining program described in example 1 is started, but the "External Start Enable" signal is removed only at certain points. The timing diagram below shows the chronological sequence effected by the "External Start Enable" and "External Stop" signals.



The next job is delayed via the External Start Enable signal

① The "External Start Enable" signal starts the first block of the machining program.
② A short pulse of the "Position Reached" signal appears between blocks that are not interconnected by a "flying change".
③ Switching function M99 is active in the sixth block.
④ The block has executed. Since the "External Start Enable" signal disables execution of blocks containing machining operations or dwells, program execution is interrupted.
⑤ The "External Start Enable" signal does not interrupt offsets or corrections.
⑥ The "External Stop" signal initiates maximum-rate deceleration.
⑦ The drive is at a standstill. The machining program is terminated and the "Machining program executing" signal is removed.

Example 3
Three jobs are started in succession.
Job 1: Absolute target position
Job 2: Relative target position
Job 3: Relative target position



2.6 Fault LED

The module is equipped with a red fault LED which is located at the right of the analog output. This LED flags faults of special IP 266 functions.

LED shows steady light in the event of the following hardware faults (automatic operation)	LED flashes
• Wirebreak or short-circuit on (5 V) incremental position encoder • No 24 V voltage supply • Polarity reversal of 24 V voltage supply • Power section off • Error in IP 266 restart routine • Open circuit between IP 266 and power section • Blocked drive • Incorrect position control (track A/A\ and B/B\ reversed)	• In the IP 266 restart routine

2.7 IP 266 Monitors

The IP 266 is equipped with a number of monitors for monitoring its I/Os. Some of these monitors are implemented at the hardware level, others at the software level.

2.7.1 Encoder Monitor

The IP 266 supports hardware and/or software monitors, depending on the type of encoder used.

The table below lists all available options:

Table 2-4. Encoder Monitor for 5 V and 24 V Encoders

Monitor	5 V encoder	24 V encoder
Software	The "Error in position control loop" signal is output when the IP 266 fails to detect pulses in ten consecutive IP cycles (10 x 3.75 ms).	
Hardware	Symmetrical encoders are also monitored for wirebreaks and short-circuits, thus enabling a faster response (even prior to the conclusion of ten consecutive IP cycles). A wirebreak or short-circuit is also flagged via the "Error in position control loop" signal.	

Note:

Software monitoring is possible only in the closed-loop control (automatic) modes.

In the event of an "Error in the position control loop", the IP 266 aborts the job currently in progress, using the specified maximum deceleration rate to do so. It then resets the existing reference point, if any, and starts the open-loop control "Follow-up" mode. The controller enable signal remains activated. You can now modify and store machine data on the IP 266.

"Follow-up" mode is terminated as soon as the machine data has been stored, and the IP is once again in closed-loop control mode.

2.7.2 Position Control Monitor

On the first automatic machining movement following IP 266 power-up, the module checks the position control direction.

If signals A and B are reversed, the encoder changes the actual value in the opposite direction to that specified by the setpoint. The IP attempts to match the actual value to the setpoint over a period of ten IP cycles. During this time, the analog voltage increases at a very rapid rate. If the two values are still progressing in opposite directions after ten cycles, the current mode is revoked, the "Follow-up" mode started, the controller enable (FUM) signal removed, and "Wrong position control direction" output.

Error recovery
Rectify the error by interchanging the signal lines.

Symmetrical encoders (5 V)	Asymmetrical encoders (24 V)
To change the counting direction, reverse A/A\ and B/B\.	To change the counting direction, reverse A* and B*.

Proceed as follows:

- Switch off the 24 V power supply for the IP 266.
- Remove the encoder cable from the module.
- Reverse the signal lines as shown in the table above.
- Reconnect the encoder and switch on the 24 V supply.

⇒ The module once again checks the position control direction, switching off its position control monitor when the check produces a correct result.
When the "Follow-up" mode is exited, the position control monitor is reenabled and is not disabled again until the new check produces a correct result.

Caution

Whenever you replace an encoder, always remember to switch off the module's 24 V power supply. Only then can the module's position control monitor detect an incorrect position control direction.

2.8 Technical Specifications

The general technical specifications include standards and test specifications which the IP 266 meets and fulfills and which were used during testing of the IP266.

UL/CSA Approbations

The following approbations have been granted for the IP 266:
UL-Recognition Mark
Underwriters Laboratories (UL) to UL standard 508, Report 116536
CSA Certification Mark
Canadian standard Association (CSA) to C22.2 standard No. 142, Report LR 48323

CE-Marking

Our products meet the requirements of EU directive 89/336/EEC "Electromagnetic Compatibility" and the harmonized European standards (EN) listed therein:

- 89/336/EEC "Electromagnetic Compatibility" (EMC Directive)
- 73/23/EEC "Electrical Equipment Designed for Use between Certain Voltage Limits" (Low-Voltage Directive)

CE In accordance with the above-mentioned EU directive, Article 10, the EU declarations of conformity are held at the disposal of the competent authorities at the address below:

Siemens Aktiengesellschaft
Bereich Automatisierungstechnik
AUT E 14
Postfach 1963

D-92209 Amberg
Federal Republic of Germany

Area of Application

SIMATIC products have been designed for use in the industrial area.
With individual approval, SIMATIC products can also be used in the domestic environment (household, business and trade area, small plants). You must acquire the individual approval from the respective national authority or testing board.

Area of Application	Requirements to:	
	Emitted Interference	Immunity
Industry	EN 50081-2 : 1993	EN 50082-2 : 1995
Domestic	Individual approval	EN 50082-1 : 1992

Observing the Installation Guidelines

S5 modules meet the requirements if you observe the installation guidelines described in the manuals when installing and operating the equipment (→ Section 3).

Electrical Specifications	
Power loss	: 4.5 W typ.
Microprocessor	: iAPx80C188
Process clock frequency	: 16 MHz (quartz frequency)
Position controller sampling time	: 3.75 ms
Memory	
EPROM	: 64 Kbytes
RAM	: 32 Kbytes (not battery backed)
EEPROM	: 8 Kbytes
Analog output	
Output signal range	: ±10 V
Accuracy	: ±0.8% at ±10 V
Digital signal representation	: 13 bits plus sign
Short-circuit protection	: Yes
Reference potential of the analog output signal	: Analog ground of the power section
Cable length	: 32 m shielded
Current carrying capacity	: 10 mA
Pulse input	
Position decoding	: Incremental
Traversing range	: ±32767.999 mm/0.1inch/deg
Input voltages for the tracks	
Differential inputs	: 5 V
Asymmetrical inputs	: 24 V
Supply voltage for the encoder (short-circuit-proof, no overload)	: 5 V/350 mA : 24 V/350 mA
Input frequency and cable length	
Symmetrical encoder (5 V)	: Max. 500 kHz for a 30 m shielded cable
Asymmetrical encoders (24 V)	: Max. 100 kHz for a 25 m shielded cable : Max. 25 kHz for a 100 m shielded cable
Input signals	: 2 pulse trains in quadrature, 1 zero pulse
Input currents	
5 V	: to RS 422
24 V	: 7.3 mA typ.

Electrical Specifications		
Digital inputs		
Input voltage range	:	±30 V
Galvanic isolation	:	No
0 signal	:	- 30 V to + 5 V
1 signal	:	13 V to 30 V
Permissible quiescent current for 0 signal	:	1.5 mA
Typ. input current at 24 V	:	7.3 mA
Digital outputs		
Output voltage range	:	20 V to 30 V
Galvanic isolation	:	no
Max. output current for "1" signal	:	100 mA
Short-circuit protection	:	Short-circuit-proof output
Length of shielded cable	:	Max. 100 m
Supply voltage		
Logic voltage generated from ext. 24 V with switched-mode power supply	:	4.7 V to 5.5 V
Power input from 24 V without outputs and 24 V encoder	:	180 mA typ.

Notes for the Machine Manufacturer

The SIMATIC programmable controller system is not a machine as defined in the EU Machinery Directive. There is therefore no declaration of conformity for SIMATIC with regard to the EU Machinery Directive 89/392/EEC.

The EU Machinery Directive 89/392/EEC regulates requirements relating to machinery. A machine is defined here as an assembly of linked parts or components (see also EN 292-1, Paragraph 3.1).

SIMATC is part of the electrical equipment of a machine and must therefore be included by the machine manufacturer in the declaration of conformity procedure.

The EN 60204-1 standard (Safety of Machinery, Electrical Equipment of Machines, Part 1, Specification for General Requirements) applies for the electrical equipment of machinery.

The table below is designed to help you with the declaration of conformity and to show which criteria apply to SIMATIC according to EN 60204-1 (as at June 1993).

EN 60204-1	Subject/Criterion	Remarks
Paragraph 4	General requirements	Requirements are met in the devices are mounted/installed in accordance with the installation guidelines. Please observe the explanations in "Notes on CE Marking of SIMATIC S5".
Paragraph 11.2	Digital input/output interfaces	Requirements are met.
Paragraph 12.3	Programmable equipment	Requirements are met if the devices for protection of memory contents against change by unauthorized persons are installed in locked cabinets.
Paragraph 20.4	Voltage tests	Requirements are met.

3 Installation Guidelines

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3 Installation Guidelines

3.1 Notes on System Configuration and Installation

Since the module is normally used as a component part of a larger system or plant, these notes are aimed at the hazard-free integration of the product in its environment.

The following are notes to be observed for the installation and startup of the product:

Warning

- Strictly follow the safety and accident prevention rules that apply in each particular case.
- In the case of equipment with a permanent power connection not provided with an isolating switch and/or fuses which disconnect all poles, a suitable isolating switch or fuses must be provided in the building wiring system (distribution board). Furthermore, the equipment must be connected to a protective ground (PE) conductor.
- In the case of equipment operated on the system voltage, make sure that the rated voltage range set coincides with the local system voltage before taking the equipment into operation.
- In the case of equipment operating on 24 V DC, make sure that the proper electrical isolation is provided between the mains supply and the 24 V supply. Use only power supply units to DIN VDE 0551 / EN 60742 und DIN VDE 0160.
- Fluctuations or deviations of the power supply voltage from the rated value should not exceed the tolerances specified in the technical specifications, otherwise function failures or dangerous conditions can occur in the electronic modules/equipment.
- Suitable measures must be taken to make sure that programs that are interrupted by a voltage dip or power supply failure resume proper operation when the power supply is restored. Care must be taken to ensure that dangerous operating conditions do not occur even momentarily. If necessary, the equipment must be forced into the "emergency off" state.
- Emergency tripping devices in accordance with EN 60204/IEC 204 (VDE 0113) must be effective in all operating modes of the automation equipment. Resetting the emergency off device must not result in uncontrolled or undefined restart of the equipment.
- Connecting cables and signal cables must be installed in such a way that inductive and capacitive interference has no adverse effects on the automation functions.
- Automation equipment and operator controls must be installed in such a way that they are adequately protected against unintentional operation.
- To prevent wire breaks on the signal side leading to undefined states in the automation equipment, the relevant hardware and software precautions must be taken in the case of I/O connections.

3.2 Wiring Arrangement, Shielding and Measures against Electromagnetic Interference

This section covers the routing of bus, signal and supply lines. The purpose of cable routing is to suppress crosstalk between cables laid in parallel.

3.2.1 Routing of Cables Within and Outside Cabinets

For electromagnetically compatible routing of cables and lines, it is advisable to subdivide the lines into the following line groups and lay the groups separately.

Group A: Shielded bus and data lines (for programmer, OP, printer, SINEC L1, Profibus, Industrial Ethernet etc.)
Shielded analog lines
Unshielded lines for DC voltage ≤ 60 V
Unshielded lines for AC voltage ≤ 25 V
Coaxial lines for monitores

Group B: Unshielded lines for DC voltage >60 V and ≤400 V
Unshielded lines for AC voltage >25 V and ≤400 V

Group C: Unshielded lines for DC and AC voltage >400 V

From the combination of individual groups in the following table, you can read off the conditions for laying the line groups.

Table 3-1 Rules for Laying of Line Combinations

	Group A	Group B	Group C
Group A	①	②	③
Group B	②	①	③
Group C	③	③	①

Legend for the table:

① Lines can be laid in common bundles or cable ducts.
② Lines must be laid in separate bundles or cable ducts (without minimum clearance).
③ Lines within cabinets must be laid in separate bundles or cable ducts; outside the cabinets but within buildings, they must be laid over separate cable routes with a clearance of at least 10 cm (3.93 in.).

3.2.2 Routing of Cables Outside Cabinets

Outside buildings, lay the lines on metal cable trays if possible. Provide the joints between cable trays with an electrical connection and ground the cable trays.

When laying lines outside buildings, you must observe the valid lightning protection and grounding measures. The following applies in general:

Lightning Protection

Where cables and lines for SIMATIC S5 controllers are to be laid outside buildings, you must apply measures for internal and external lightning protection.

Outside the buildings, lay your lines either

- in metal conduits grounded at both ends,
  or
- in concreted cable ducts with continuously connected reinforcement.

Protect the signal lines from overvoltages by means of

- varistors
  or
- inert gas-filled surge diverters.

Fit these protective devices at the cable entry into the building.

> **Note**
>
> Lightning protection measures always require an individual assessment of the entire installation. For clarification, please consult your local Siemens Office or a company specializing in lightning protection, such as Messrs. Dehn und Söhne in Neumarkt both Germany.

Equipotential Bonding

Ensure adequate equipotential bonding between the connected equipment.

3.2.3 Equipotential Bonding

Between separate sections of an installation, potential differences can develop if

- programmable controllers and I/O devices are connected via non-floating links, or
- cable shields are connected at both ends and are grounded at different parts of the system.

Different AC supplies, for example, can cause potential differences. These differences must be reduced by installing equipotential bonding conductors to ensure functioning of the electronic components.

The following points must be observed for equipotential bonding:

- The lower the impedance of the equipotential bonding conductor, the greater is the effectiveness of equipotential bonding.
- Where shielded signal lines are laid between the relevant sections of the system and connected at both ends to the ground/protective conductor, the impedance of the additional equipotential bonding conductor must not exceed 10 % of the shield impedance.
- The cross-section of the equipotential bonding conductor must be rated for the maximum circulating current. The following cross-sections of copper have proved to be satisfactory in practice:
  - 16 mm² for equipotential bonding conductors of up to 200 m (656 ft.) in length
  - 25 mm² for equipotential bonding conductors of more than 200 m (656 ft.) in length.
- Use copper or zinc-plated steel for equipotential bonding conductors. They must be given a large-area connection to the ground/protective conductor and protect it from corrosion.
- The equipotential bonding conductor should be laid so that the smallest possible areas are enclosed between the equipotential bonding conductor and signal lines (see Figure 3-1).

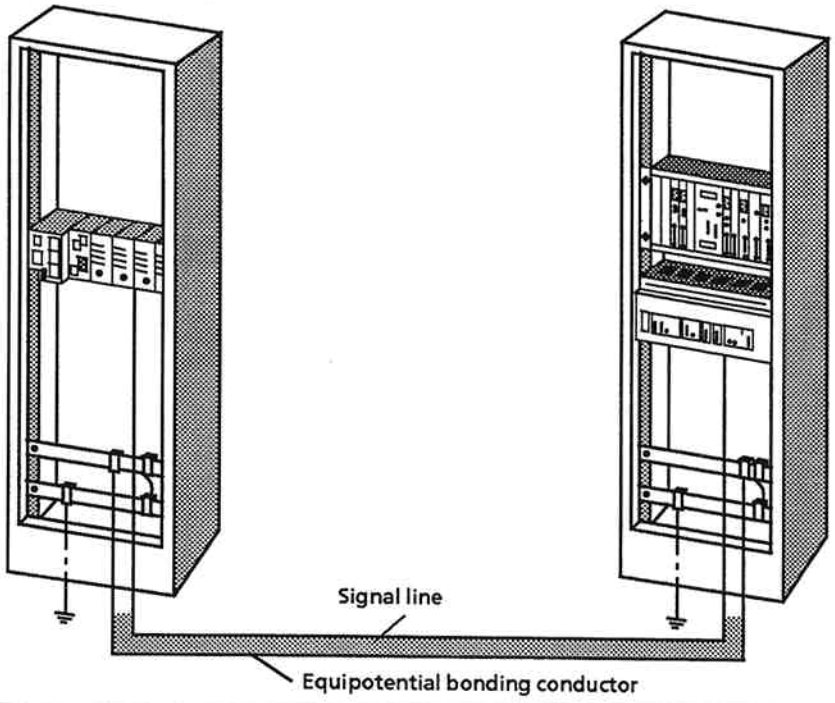

Figure 3-1. Routing of Equipotential Bonding Conductor and Signal Line

3.2.4 Shielding of Cables and Lines

Shielding is a method of attenuating magnetic, electrical or electromagnetic interference fields.

Interference currents on cable shields are passed to ground via the shield bar which is electrically connected to the housing. A low-impedance connection to the protective conductor is particularly important so that these interference currents themselves do not become an interference source.

Where possible, only use lines with a braided shield. The coverage density of the shield should be more than 80 %. Avoid lines with a foil shield because the foil can be very easily damaged by tensile strain and compression during fitting; this results in reduced effectiveness of the shield.

As a rule, line shields should always be connected at both ends. This is the only way to achieve a good degree of interference suppression in the higher frequency region.

Only in exceptional cases should the shield be connected at one end only, as this only achieves attenuation of the low frequencies. Single-ended shield connection may be more advantageous when:

- an equipotential bonding conductor cannot be laid;
- analog signals (of a few mV or µA) are to be transmitted;
- foil (static) shields are used.

With data lines for serial communication, always use metal or metallized connectors. Secure the shield of the data line to the connector case. Do **not** connect the shield to PIN 1 of the connector.

For stationary operation, it is advisable to fully strip the insulation from the shielded cable and connect it to the shield/protective conductor bar.

Note

In the event of potential differences between ground points, a circulating current may flow through the shield connected at both ends. In this case, install an additional equipotential bonding conductor.

Please observe the following points when connecting the shield:

- Use metal cable clamps for securing the braided shield. The clamps must enclose the shield over a large area and provide a good contact (see Figure 3-2).
- Connect the shield to a shield bar immediately after the cable entry into the cabinet. Route the shield as far as the module but do **not** connect it there again.

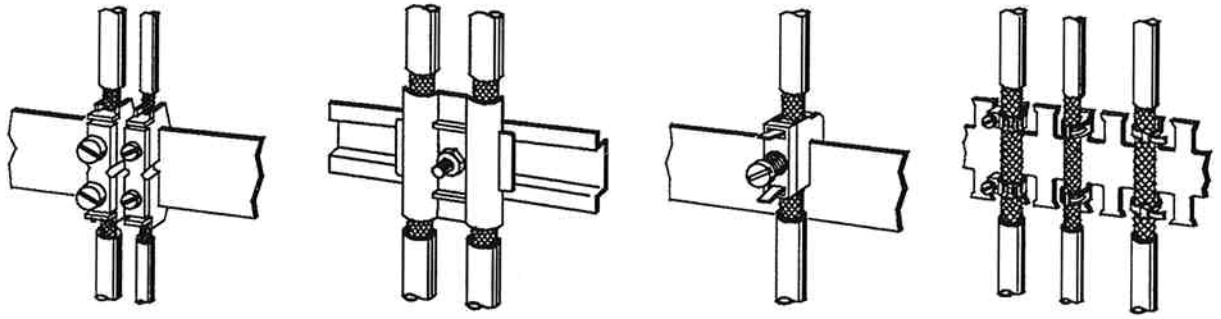

Figure 3-2. Examples of Securing Shielded Lines with Cable Clamps

3.2.5 Special Measures for Interference-Free Operation

Arc Suppression Elements For Inductive Circuits

Normally, inductive circuits (e.g. contactor or relay coils) energized by SIMATIC S5 do not require to be provided with external arc suppressing elements since the necessary suppressing elements are already integrated on the modules.

It only becomes necessary to provide arc supressing elements for inductive circuits in the following cases:

- If SIMATIC S5 output circuits can be switched off by additionaly inserted contactors (e.g. relay contactors for EMERGENCY OFF). In such a case, the integral suppressing elements on the modules become ineffective.
- If the inductive circuits are ***not*** energized by SIMATIC S5.

You can use free-wheeling diodes, varistors or RC elements for wiring inductive circuits.

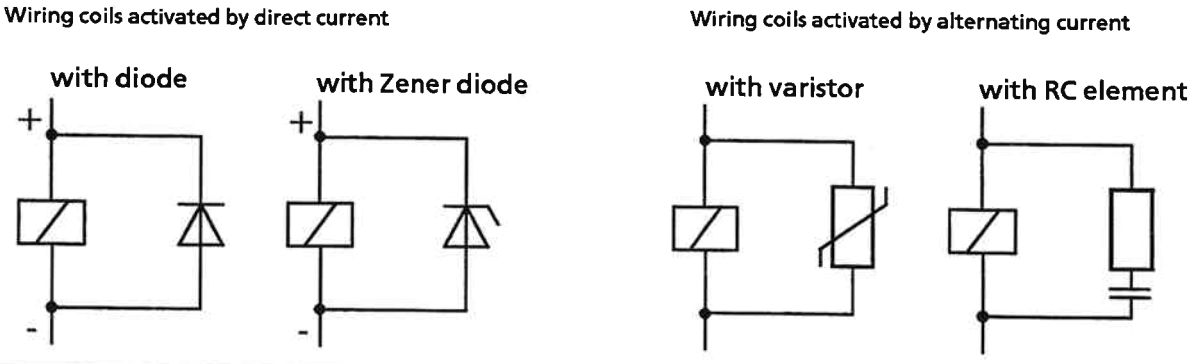

Figure 3-3. Wiring Coils

3.3 Peculiarities of IP 266 Installation

3.3.1 Safety

It is absolutely essential to the overall safety concept that the switching elements discussed in the following be installed and matched to your system.

- EMERGENCY STOP switch for shutting down the entire system.
- Hardware limit switches for restricting the traversing range.
  These switches initiate a preprogrammed deceleration procedure, and can be connected as NC or NO contacts to the IP 266's digital inputs.
- EMERGENCY limit switches for a direct shutdown of the power section. These switches are not reached until the hardware switches have been overrun.

> **Caution**
>
> The failsafe switches for the power section must be designed as NC contacts (e. g. failsafe shutdown in the event of a wirebreak).

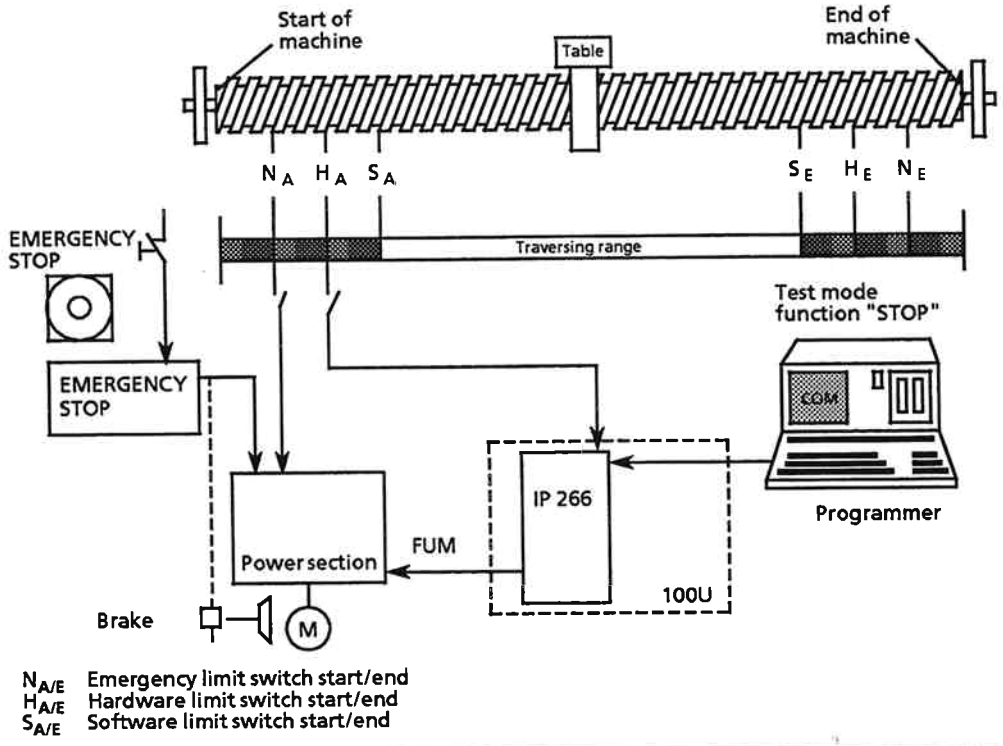

Figure 3-4. Linear Axis with Range Limit Switches

3.3.2 Cable Connections on the IP 266

Caution

All connections on the IP 266 (inputs, outputs and the 24 V power supply) require shielded cables to ensure noise immunity.

3.3.3 Module Installation/Removal

- Installation
  Before installing an I/O module, you must set the bus module's coding element to the module type.
  Setting the coding element:

Caution

Before installing a new bus module or adjusting the coding element, always remember to switch off the programmable controller.

A code digit is imprinted on the frontplate of every I/O module. A white coding pin, which functions as "key", is located on the back of the every module. How this "key" is set depends on the module, and the setting cannot be changed. The bus module is equipped with a counterpart to this key for each slot, a white, rotary coding element which serves as "lock". Using a screwdriver, set the "lock" on the bus module in accordance with the module identifier.

The IP 266 can be addressed in the same manner as an analog module in slots 0 to 7.

To install the IP, you need a free bus module slot in this range.

- ▸ Switch on the 24 V power supply for the IP 266.
- ▸ Hinge the module onto the top of the bus module.
- ▸ Swing the IP module down toward the bus module.
- ▸ Press down firmly and
- ▸ screw the IP into place.

- Removing the IP 266
  - ▸ Switch off the 24 V power supply for the IP 266!
  - ▸ Set the PLC to STOP!
  - ▸ Switch off the power section!
  - ▸ Disconnect
    - the cable to the power section from the IP 266's analog output
    - the programmer cable from the programmer port
    - the incremental decoder cable from the encoder interface!
  - ▸ Loosen the fixing screw on the module!
  - ▸ Remove the module from the programmable controller!

Note:

When the module is disconnected from the supply voltage and removed from the PLC, all data in its RAM is lost.
Any data that is to be retained must be saved before disconnecting the module.

3.3.4 Replacing the Position Encoder

The steps you must take to remove the encoder for repair or replacement are listed below, and must be carefully observed.

Proceed as follows to remove the encoder:

- Switch off the 24 V power supply for the module.
- Disconnect the encoder cable from the module.
- Repair the encoder or insert a new one.
- Connect the encoder and switch on the module's 24 V power supply.

The position control monitor is activated when an automatic mode that outputs an analog setpoint greater than 5 V is invoked.
The encoder pulses are compared to the setpoint over a period of ten IP cycles.

Once the IP 266 has ascertained that the counting direction for setpoint and actual value are in conformance, the monitor is deactivated.

Caution

The module's 24 V power supply must always be switched off before removing the encoder for repair or replacement, as only then can the monitor detect position control errors.
Once an encoder has been replaced or repaired and reinstalled, the new position of the zero mark makes reproduction of an old reference point, if any, impossible.

4 Fundamentals of Positioning

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4 Fundamentals of Positioning

Positioning means bringing a load to a certain position within a specific period of time, making allowance for force and torque.

Various methods are used to perform this task.

4.1 Positioning Methods

A drive can be positioned in one of two ways:
- under open-loop control
- under closed-loop control

The figure below shows the options available in conjunction with S5-100U programmable controllers.

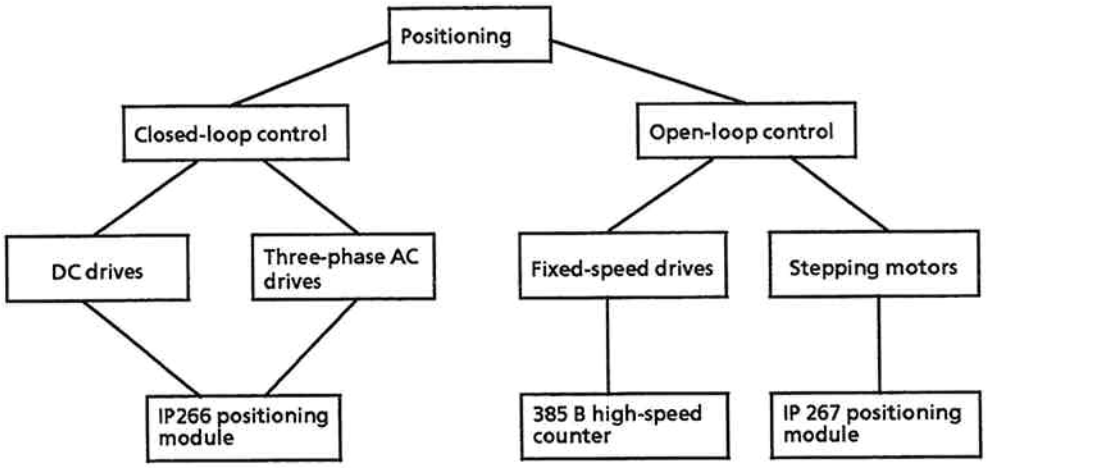

Figure 4-1. Positioning Methods

A setpoint generator is required for programmable positioning operations, regardless of whether positioning is in an open or closed loop.

The setpoint generator's output variable depends on a number of parameters:
- the difference between the current position of the axis and the target position
- speed
- acceleration/deceleration

Open-loop positioning

When positioning under open-loop control, the setpoint generator provides a time-dependent speed or speed setpoint $V_{setp}(t)$. This is the voltage used to drive the power section. Drive movement is governed by this voltage. The setpoint generator outputs the setpoint voltage until the drive has reached the target position.

During positioning, the setpoint generator is not informed of the current position. There is thus no guarantee that the drive's final position is identical to the required target position.

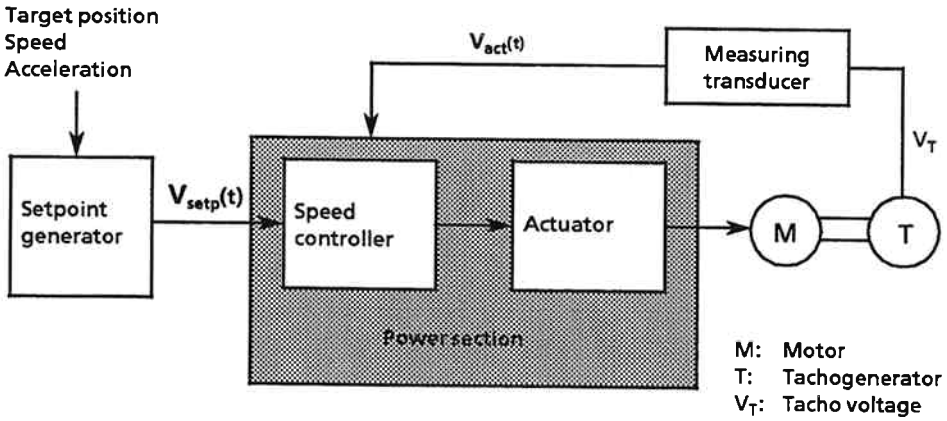

Figure 4-2. Open-Loop Positioning

Closed-loop positioning

When positioning under closed-loop control, the drive's current actual position is compared with the setpoint position computed by the setpoint generator. The difference between these two values is fed to the position controller, which supplies a voltage setpoint. This setpoint is proportional to the positioning speed.

During positioning, deviations are picked up and fed continually to the position controller, thus enabling precise positioning.

Following a positioning operation, the final position is maintained. The position controller is able to detect disturbances and compensates any positional deviations.

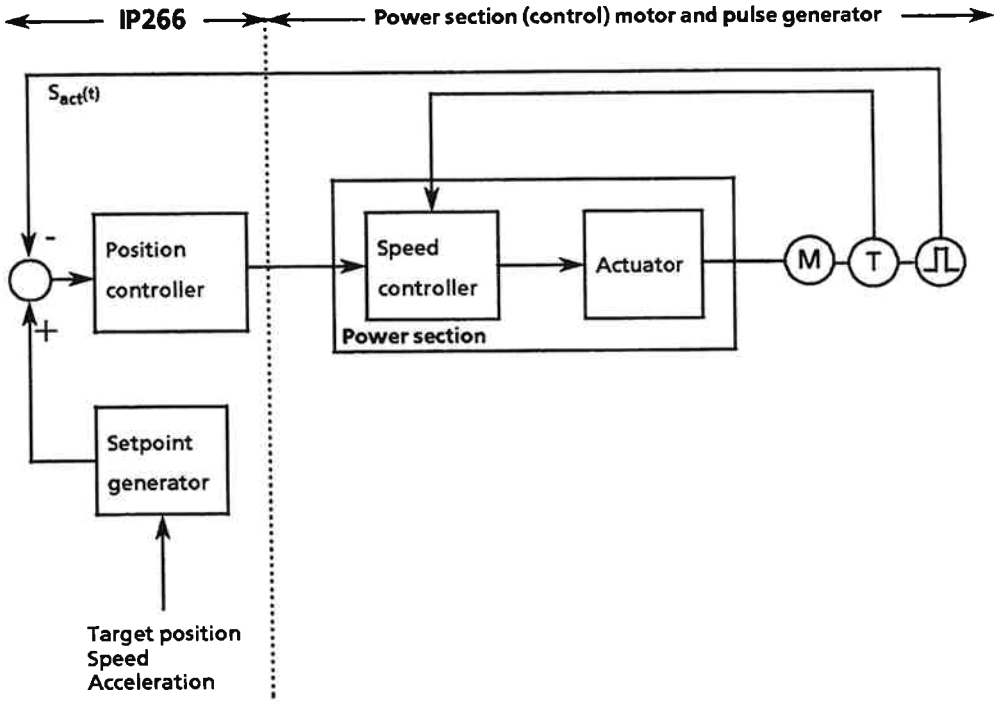

Figure 4-3. Schematic Diagram for Closed-Loop Positioning

4.2 Components of a Position Control System

The IP 266's position controller enables precise positioning of the drive. The following components are required for a position control system:

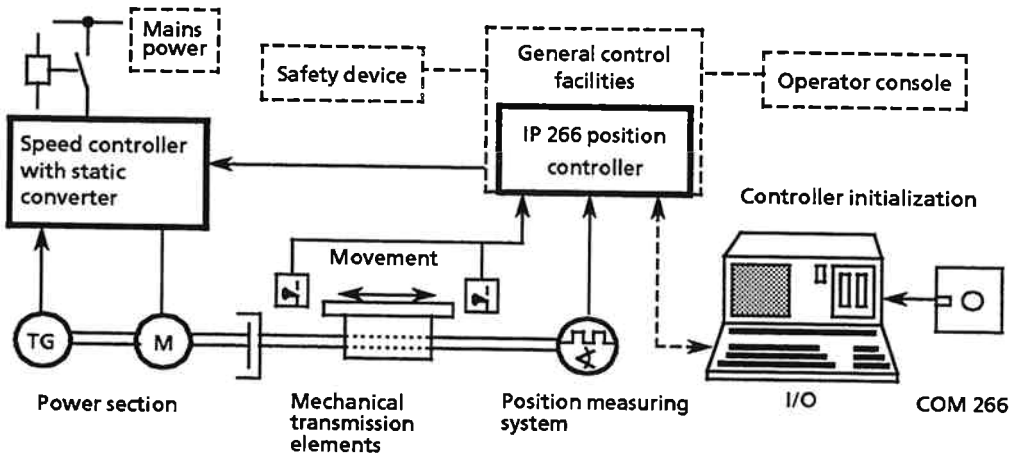

Figure 4-4. Components of a Position Control System

- Power section
  The power section is driven via the IP 266's analog output, and comprises rotational speed controller and static converter.

- Motor
  The power section drives the motor in accordance with the directives from the IP 266.

- Mechanical transmission elements
  In addition to the axis, the mechanical transmission elements include gears and coupling systems.

- Position measuring system
  The position measuring system measures movement. An incremental position encoder supplies the IP 266 with pulses. The number of pulses is proportional to the path travelled.

- I/O
  The term "I/O" is used collectively for all other auxiliary facilities.
  The most important of these are
  - the limit switches used to limit the traversing range
  - the programmer used in conjunction with the COM 266 software to service the IP 266.

4.3 Terms

4.3.1 Positioning

Positioning means bringing a load to a defined position within a specific period of time, making allowance for force and torque.

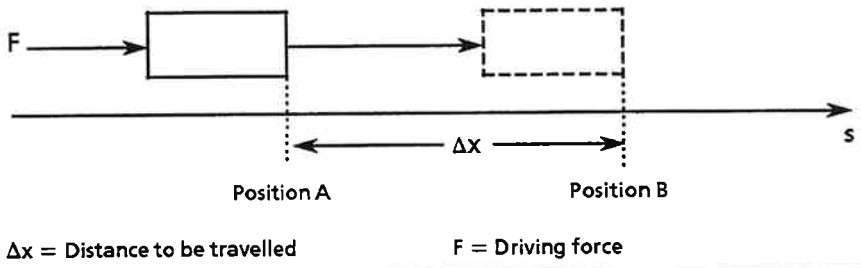

Figure 4-5. Principles of Positioning

4.3.2 Setpoint, Actual Value and Following Error

Execution of a positioning operation requires specification of

- the target coordinate
- acceleration and deceleration rates
- positioning velocities.

Based on this data, the IP 266 computes a theoretical speed characteristic. An ideal drive system would directly follow this characteristic. The IP 266 provides a voltage value at its analog output which is proportional to the theoretical speed characteristic. This value is referred to as the **setpoint**, and is computed by the IP 266's setpoint generator.

Driven by the power section, the drive travels a specific path. In accordance with the distance traversed, the position encoder generates a number of pulses which are evaluated by the IP 266's input section. The actual position of the drive is computed from the pulse count and the value for the encoder resolution. This value is called the **actual value**.

The difference between the setpoint $S_{setp}(t)$ and the actual value $S_{act}(t)$ is referred to as the following error Δs:

$$\Delta s = S_{setp}(t) - S_{act}(t)$$

Figure 4-6 shows the characteristic of the following error during a positioning operation.

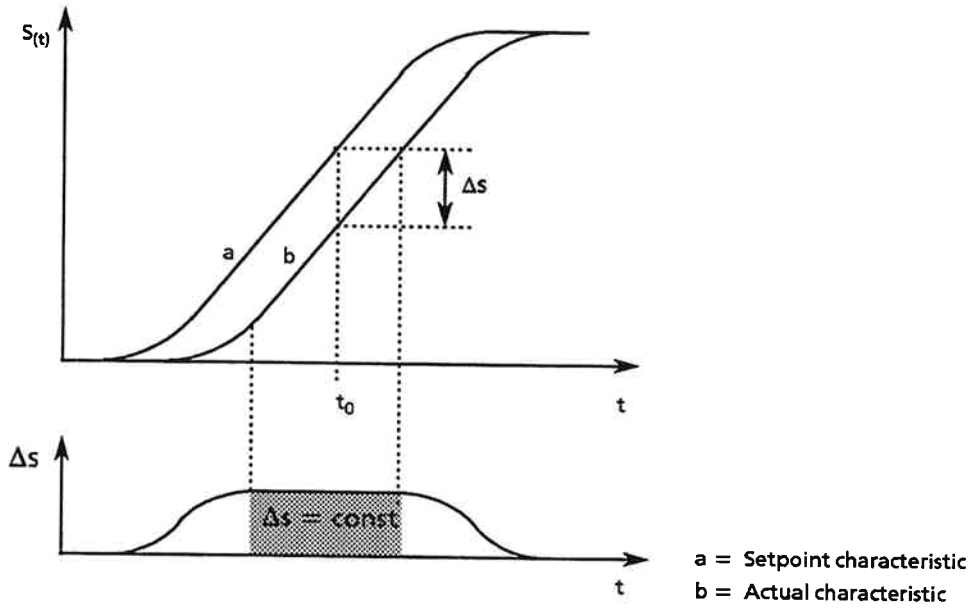

Figure 4-6. Characteristic of the Following Error During a Positioning Operation

4.3.3 Relationships Between $a_{(t)}$, $v_{(t)}$ and $s_{(t)}$

In order to position to a defined target, the drive must be moved at a specific speed. The IP 266 computes the acceleration and deceleration rates from the machine data. The result is the basic characteristic of a positioning operation.

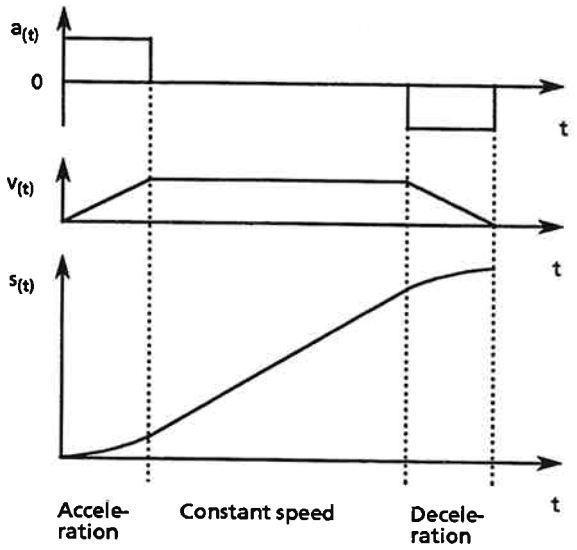

Figure 4-7. Relationships Between $a_{(t)}$, $v_{(t)}$ and $s_{(t)}$ (Characteristic of a Positioning Operation)

The slope of the speed ramp is a measure of the acceleration rate. It is specified in the unit [m/s^2], and is generally obtained from the following equation:

$$a = \frac{v}{t}$$

The IP 266 takes into consideration only a **constant** acceleration or deceleration rate for each direction. This results in a linear equation for speed $v_{(t)}$.

$$v = a \cdot t$$

The unit for speed is [m/s].
The drive's path is then computed from the speed curve.

In the sections with constant acceleration or deceleration, the path traversed has a parabolic time characteristic

$$s = \frac{1}{2} \cdot a \cdot t^2$$

In the sections with constant speed, the path is computed as follows:

$$s = v \cdot t$$

4.4 IP 266 Modes

In order to compute the setpoint variables $S_{setp}(t)$ and $V_{setp}(t)$ correctly, the IP 266 requires data which provides a complete description of the drive system.
This data is stored in the module's RAM, and is referred to as **machine data.**

A mode may be
- a sequence of motions
- a coordinate shift
- a machining program call

A machining program can be stored on the IP 266 to enable automatic execution of a sequence of motions or special functions (such as dwell or zero offset).

5 Machine Data, Modes and Traversing Programs

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5 Machine Data, Modes and Traversing Programs

The IP 266 can execute positioning operations only when it has correct machine data at its disposal. You cannot start a positioning operation until you have provided the IP with this data.

The machine data and all permissible parameters are discussed in detail in Section 5.1. In Section 6, you will find information on how to enter these values and transfer them to the IP 266.

5.1 Machine Data

The machine data describes the properties of

- the drive system,
- the position encoder,
- and the position controller.

The IP 266 needs machine data in order to compute the correct speed and path. Errored data can therefore result in an unpredictable or incorrect system response.

You can also enter machine data values for coordinate shifts and corrections which are needed, for instance, if tool dimensions change.

Table 5-1 shows you which items of machine data you need for different tasks. The table also provides cross-references to the sections describing these data items.

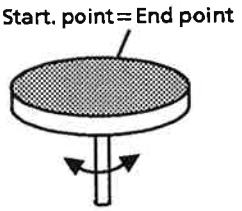
Table 5-1. IP 266 Machine Data

Task	Machine Data Item	Parameter Specifications	Permissible Units
Hardware description → **Section 5.1.1**	Module Axis type	1 to 99 linear, rotary	
Pos. decoding and resolution → **Section 5.1.2**	Unit of measure Encoder type Travel per encoder revolution Pulses per encoder revolution	mm, in, deg 5 V, 24 V 0.001 to 400.000 1 to 65 000	 [mm;0.1 in;deg] [pul]
Machining range → **Section 5.1.3**	Software limit switch-start (linear axis) Software limit switch-end (linear axis) Start of traversing range (rotary axis) End of traversing range (rotary axis) Reference point	± 32 767.999 ± 32 767.999 ± 32 767.999 ± 32 767.999 ± 32 767.999	[mm;0.1 in;deg] [mm;0.1 in;deg] [mm;0.1 in;deg] [mm;0.1 in;deg] [mm;0.1 in;deg]
Speeds → **Section 5.1.4**	Maximum speed Forward speed for JOG 1 Reverse speed for JOG 1 Forward speed for JOG 2 Reverse speed for JOG 2 Incremental speed Reference point approach speed 1 Reference point approach speed 2	1 to 65 000 1 to 65 000 1 to 65 000 1 to 65 000 1 to 65 000 1 to 65 000 1 to 65 000 1 to 65 000	$\left[\frac{mm}{min}\right]$ $\left[\frac{0.1\ in}{min}\right]$ $\left[\frac{deg}{min}\right]$
Acceleration Deceleration → **Section 5.1.5**	Maximum deceleration rate Forward acceleration Forward deceleration Reverse acceleration Reverse deceleration	10 to 9 999 10 to 9 999 10 to 9 999 10 to 9 999 10 to 9 999	$\left[\frac{mm}{s^2}\right]$ $\left[\frac{0.1\ in}{s^2}\right]$ $\left[\frac{deg}{s^2}\right]$
Controller parameters → **Section 5.1.6**	Servo gain (kv) factor Maximum following error Monitoring of the following error Zero-speed monitoring	0.1 to 99.9 0.001 to 99.999 on, off 0.001 to 64.999	[1/s] [mm;0.1 in;deg] [mm;0.1 in;deg]
Correction parameters → **Section 5.1.7**	Zero offset 1 Zero offset 2 Zero offset 3 Zero offset 4 Tool length compensation Backlash compensation	± 32 767.999 ± 32 767.999 ± 32 767.999 ± 32 767.999 ± 32 767.999 0.000 to 64.999	[mm;0.1 in;deg] [mm;0.1 in;deg] [mm;0.1 in;deg] [mm;0.1 in;deg] [mm;0.1 in;deg] [mm;0.1 in;deg]
Miscellaneous parameters → **Section 5.1.8**	Reference point direction PLC BCD-coded Polarity of the hardware limit switches IP stop on CPU stop	forw, rev yes, no pos, neg yes, no	

5.1.1 Hardware Description

Module
To distinguish between the IP 266 modules in a PLC, you can assign each IP a number between 1 and 99.

Axis type
This machine data item is used to specify either a rotary or a linear axis. A linear axis has a restricted traversing range, which must be limited via hardware limit switches.



There is no limit to the traversing range of a rotary axis. On each revolution, the axis goes from the starting point to the end point. The values assigned for these points specify the traversing range of the axis. Both points are at the same physical position. One complete revolution of the axis does nothing more than change the actual value indication from the start value to the end value of the traversing range.

5.1.2 Position Decoding and Resolution

Unit of measure
You may use one of the following units of measure on the IP 266 for all positional specifications:
- Metric system with 0.001 mm as base unit
- Inch with 0.001 inches as base unit
- Degree with 0.001 degrees as base unit

A base unit is the smallest unit that may be entered as the unit of measure.
The specified unit of measure also applies to
- speeds
- acceleration rates and
- encoder resolution

If you have chosen [deg] as the unit of measure, the speed is specified in [deg/min].

Encoder type
You may connect the following types of encoder to the IP 266:
- Encoders with symmetrical 5 V output signals
- Encoders with asymmetrical 24 V output signals

The encoder type is specified in the machine data's "Encoder type" parameter.

In order to ensure precise measuring of the drive's current position, you must use an encoder whose resolution meets with your specific requirements.
Two items of data are needed to compute the resolution:
- Travel per encoder revolution and
- Pulses per encoder revolution

Travel per encoder revolution
The "travel per encoder revolution" depends on your drive system, and should take accurately into account all transmission elements, such as couplings and gears, which are located between the motor and the incremental encoder.

Pulses per encoder revolution
The "pulses per encoder revolution" can be found in the data sheet for your encoder.

Resolution
The IP 266 distinguishes between two resolution types:

- External resolution is calculated from the actual technical specifications of the connected components. The IP 266 processes an external resolution of 0.4 to 400.0.
- Internal resolution is calculated from the external resolution on the basis of the internally used quadruple evaluation over factor 0.25.

Travel per encoder revolution Resolution	[µm] [µm/pul]	[0.0001 inch] [0.0001 inch/pul]	[0.001 deg] [0.001 deg/pul]

Use the following formula to compute the resolution:

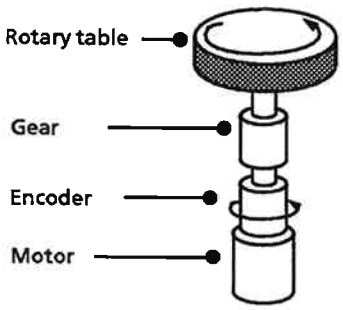
$$A = \frac{\text{Travel per encoder revolution}}{\text{Pulses per encoder revolution}}$$

When dimensioning your system, you must therefore ensure that the internal resolution never falls below the value 0.1. This means that a minimum external resolution of 0.4 is dictated by the external hardware.

Comparison of the resolution types

Internal resolution	External resolution
$0.1 \leq \frac{\text{Path/revolution}}{\text{Pulses/revolution}} \leq 100$	$0.4 \leq \frac{\text{Path/revolution}}{\text{Pulses/revolution}} \leq 400$

Special characteristics of the rotary axis:
To enable reproducibility of the reference point when using a rotary axis, the ratio between the full machining range and the distance travelled by the drive during one encoder revolution must be an integer number.



Example:
Traversing range: 0° to 360°
During one encoder revolution, the rotary table revolves 20°.
The ratio of these two values must be an integer number.

$$\frac{360°}{20°} = 18$$

Example 1:
An incremental encoder generates 1000 pulses per revolution. During this time, the reference point on the axis travels a distance of 5 mm.
The resolution is thus:

$$A = \frac{5\ \text{mm}}{1000\ \text{pul}}$$

$$A = 5\ \mu\text{m/pul}$$

Example 2:
In your drive system, you are using an encoder that generates 1000 pulses per revolution. You are using a rotary axis, and have initialized it in [deg]. During one encoder revolution, the drive moves 10 degrees.

Based on these values, the encoder resolution computes to the following:

$$A = \frac{10\ \text{deg}}{1000\ \text{pul}}$$

$$A = 0.01\ \text{deg/pul}$$

$$A = 10 \cdot 0.001\ \text{deg/pul}$$

Example 3:
The table below lists a number of examples of permissible and impermissible parameter values:

Travel per revolution	Unit	Pulses per revolution	Resolution	Unit	Permissible
1 mm	[µm]	5000	0.200	[µm/pul]	•
200 deg	[0.001 deg]	1000	200	[0.001 deg/pul]	
40 deg	[0.001 deg]	500	80	[0.001 deg/pul]	•
10 in	[0.0001 in]	1800	55.56	[0.0001 in/pul]	•
100 in	[0.0001 in]	2000	500	[0.0001 in/pul]	

Encoder direction of rotation
The direction in which the encoder revolves is ascertained from the encoder's two signals, which are displaced from each other by 90 deg.

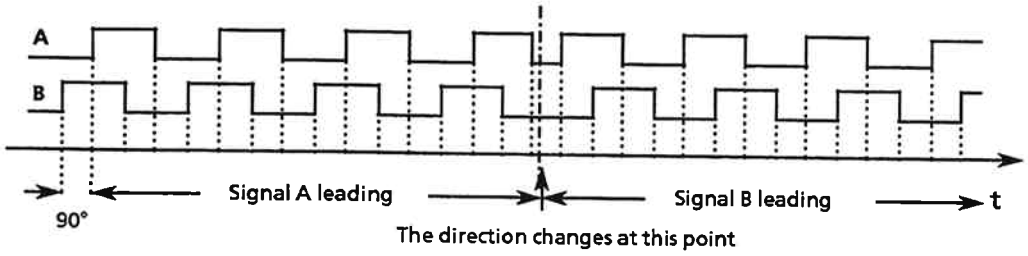


Figure 5-1. Encoder Signal Evaluation

5.1.3 Traversing Range

Software limit switches (linear axis only)
The software limit switches are used to define the traversing range of your drive. In a fully configured drive system, the software limit switches define the internal boundaries of the traversing range.

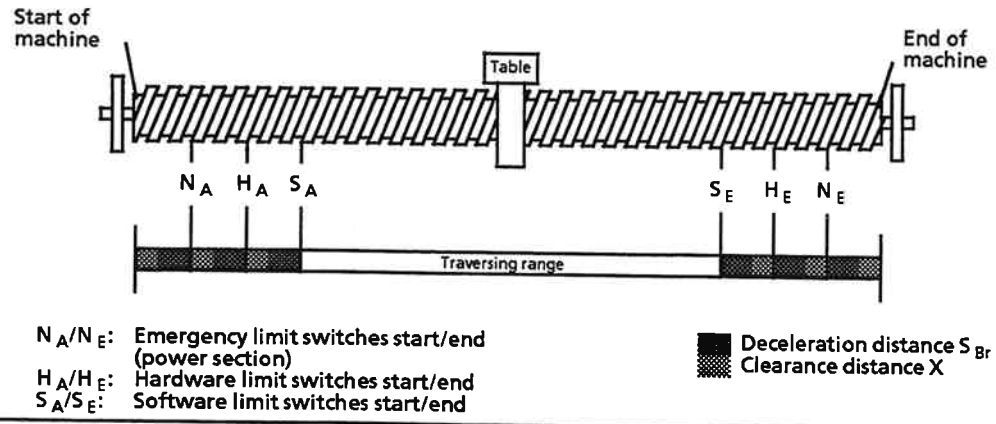


Figure 5-2. Linear Axis with Range Limit Switches (not to scale)

Note:

The software limit switches are active only when a valid reference point is set.

Target specifications outside the traversing range are not processed. The drive is decelerated at the software limit switches. Different values may be specified in the machine data for forward and reverse deceleration.

Start/end of traversing range (rotary axis only)

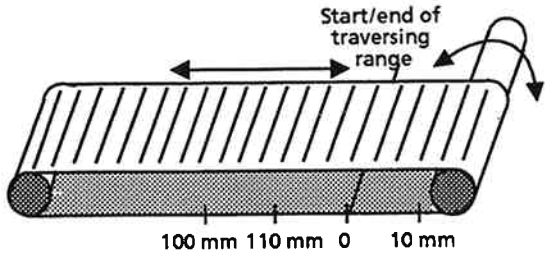


Figure 5-3. Rotary Axis, Programmable in mm/inch/deg

In the case of a rotary axis, the values define the limits of the display range. The start and the end of the traversing range are at the same physical location.

At the range limits, the display changes
- from the start value to the end value
  or
- from the end value to the start value

depending on the direction of rotation.

Absolute target specifications must lie within this range, while relative specifications may exceed it.

The hardware limit switches remain in force as additional protection for the drive system.

Reference coordinate
The reference point is used to calibrate the axis. Its location can be specified via the "Set/Approach to reference point" mode (see Section 5.3.5). The "reference coordinate" machine data parameter is used to assign a value to this position. The value must lie within the maximum range limits. When you define the reference point coordinate, you also define the following coordinates:
- coordinate basic origin
- software limit switches

You can make absolute target specifications only in a system with a defined reference point.

5.1.4 Speeds

The speeds specified in the machine data define the true speeds of the drive system, and depend on

- the motor rotational speed
- the number of encoder pulses per revolution
- the travel per encoder revolution

The absolute values for all speeds must be less than or equal to the maximum speed. Input values must be in the range from 1 to 65,000. Depending on the parameter assignments, the IP expects values in [mm/min], [deg/min] or [0.1 inch/min].

Maximum speed
Under IP 266 control, the drive reaches the maximum speed with a setpoint of ±10 V.

> **Caution**
>
> The maximum speed must be computed from the technical specifications for the complete drive system (motor, axis, encoder, and so on).

Jogging speed
For jog mode, you must define four speeds in the machine data.

Table 5-2. Speeds for Jog Mode

Direction	Speed	
Forward	Jog 1	Jog 2
Reverse	Jog 1	Jog 2

These four parameters define the speeds for modes Jog 1 and Jog 2.
The specifications for Jog 2 also apply for "Controlled jog", i. e. jogging under open-loop control.

Incremental speed
The incremental speed is used as the positioning speed in

- incremental feed mode absolute
- incremental feed mode relative

When a traversing program is generated in TEACH-IN mode, this speed is taken over into the new program.

Reference point approach speed
The IP 266 takes recourse to two speeds in order to determine the reference point. To enable a purposeful reference point approach, you should specify two different speeds. Section 5.3.5 explains how these speeds are used.

> **Caution**
>
> Reference point approach speed 1 must be greater than reference point approach speed 2.

5.1.5 Acceleration Rates

In order to reach the speed initialized for the specified mode, the drive must accelerate.

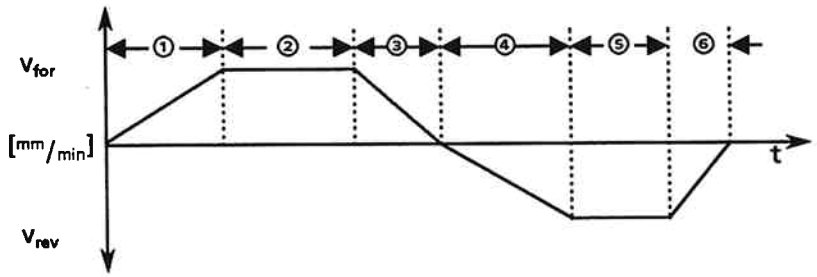
The following five values may be entered in the machine data:
- Maximum deceleration rate
- Forward acceleration rate
- Forward deceleration rate
- Reverse acceleration rate
- Reverse deceleration rate

The absolute maximum deceleration rate must be greater than or equal to all other acceleration or deceleration rates.

This deceleration rate is used to stop travel
- when the drive has reached a hardware limit switch or
- when an external Stop command was issued.

The values must be in the range from 10 to 9 999. The entry must be in [mm/s²], [deg/s²] or [0.1 inch/s²].

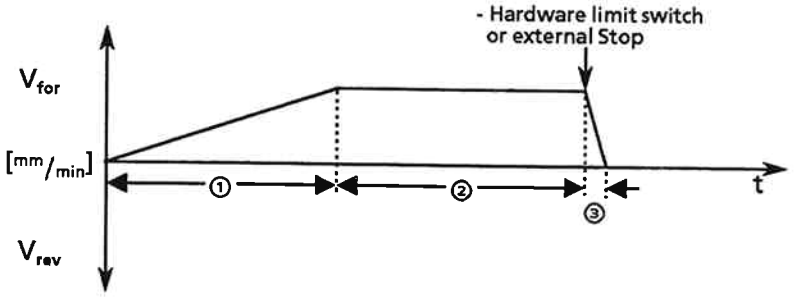
Example 1:
This example illustrates the use of the various acceleration and deceleration rates in normal operation.



① Forward acceleration
② Constant speed forward
③ Reverse deceleration
④ Reverse acceleration
⑤ Constant speed in reverse
⑥ Reverse deceleration

Figure 5-4. Acceleration and Deceleration of the Drive System in Both Directions

Example 2:
When the drive reaches a hardware limit switch, it decelerates at the maximum deceleration rate. This is also the case when an external Stop command is issued.



① Forward acceleration
② Constant speed forward
③ Maximum deceleration

Figure 5-5. Maximum Deceleration Rate on Abort of a Traversing Movement

5.1.6 Controller Parameters

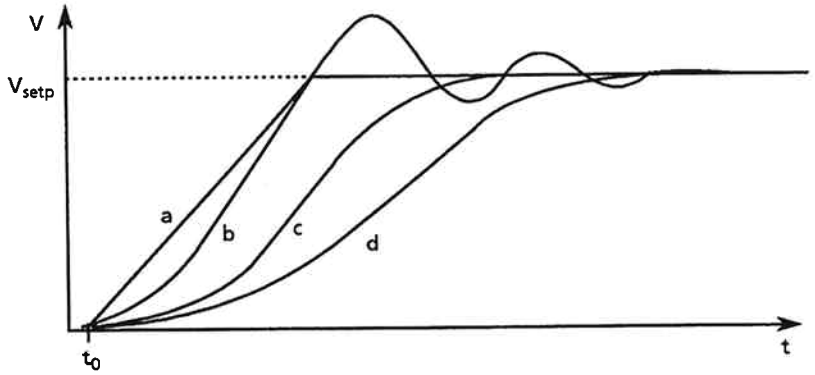
Kv (servo gain) factor
The IP 266 uses a proportional-action controller (P controller) for position control. The only parameter a P controller needs is the servo gain factor Kv. The unit for the Kv factor is [1/s]; the value range is from 0.1 to 99.9 [1/s].

The higher the Kv factor, the better the control loop's dynamic response.

Caution

An excessively high Kv factor results in
- oscillation,
- instability and
- an impermissibly high machine load

The maximum Kv factor depends on
- the drive's design or dynamic response and
- the quality of the machine.



a: Setpoint characteristic
b: Kv factor too high →system oscillates
c: Kv factor adequate →optimum controller initialization
d: Kv factor too low →controller too slow; setpoint is reached very slowly

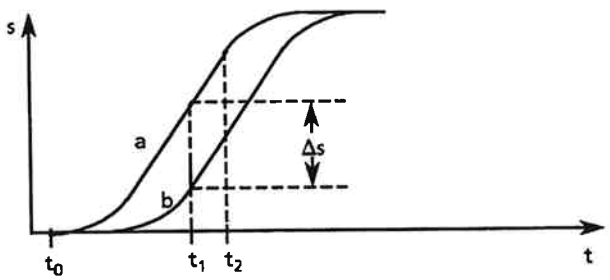
Figure 5-6. Control Response of the Position Controller in Dependence on the Kv Factor

For best results, start with a very low initial value (1 to 2 $^1/_s$) as the basis for subsequent optimization.

Maximum following error
The difference between the actual position and the setpoint position is called the following error. A field is provided in the machine data for specification of the maximum following error, which must be in the range from 0.001 to 99.999.

If the following error exceeds the specified value, the IP 266 aborts the positioning operation and displays "Maximum following error exceeded" on the programmer.

The position controller remains active. The axis does not come to a stop until the following error has been brought back into range.



a: Setpoint characteristic
b: Actual characteristic
Δs: Following error
t_0: Start of positioning
t_1: The following error has reached its maximum range limit
t_2: Following error is brought back into range

Figure 5-7. Following Error in Dependence on Setpoint and Actual Value

The following error changes in direct proportion to the traversing speed in accordance with the following equation:

$$\Delta s = \frac{v}{kv} \quad [mm]$$

If the actual value stops changing during a positioning operation, for instance because
- the encoder failed or
- the power section was switched off,

the following error continually increases.

$$\Delta s = s_{set} - s_{act}$$

The driving voltage for the power section increases in proportion to the increase in the following error. If the voltage exceeds 5 V, the current operation is aborted with "Position control loop interrupted". The IP 266 automatically switches to follow-up mode, a mode in which the position controller is disabled.

Following error monitoring

You can choose between "ENABLE" and "DISABLE". If you choose "DISABLE", the following error is no longer monitored and may therefore exceed the maximum value of 99.999.

Zero-speed monitoring

The IP 266's "Zero-speed monitoring" function also monitors the following error (difference between actual value and setpoint). In contrast to following error monitoring, zero-speed monitoring is effective only when the drive is at a standstill. Because the following error is expected to be very small when the drive is at zero speed, the value range is more closely restricted, being only from 0.001 to 64.999. When this function has been activated, the error message "Zero-speed monitor responded" is displayed on the programmer. Aside from this error message, there is no further reaction of any kind.

Note:

The tolerance limit for zero-speed monitoring may not exceed the maximum following error.

5.1.7 Correction Parameters

Tool wear necessitates adjustments to the plant or the program. These adjustments can be made via various correction parameters.

The use of zero offsets makes it possible to invoke a subroutine in the traversing program for performing similar or identical positioning operations.
Example: Using a zero offset (ZO)

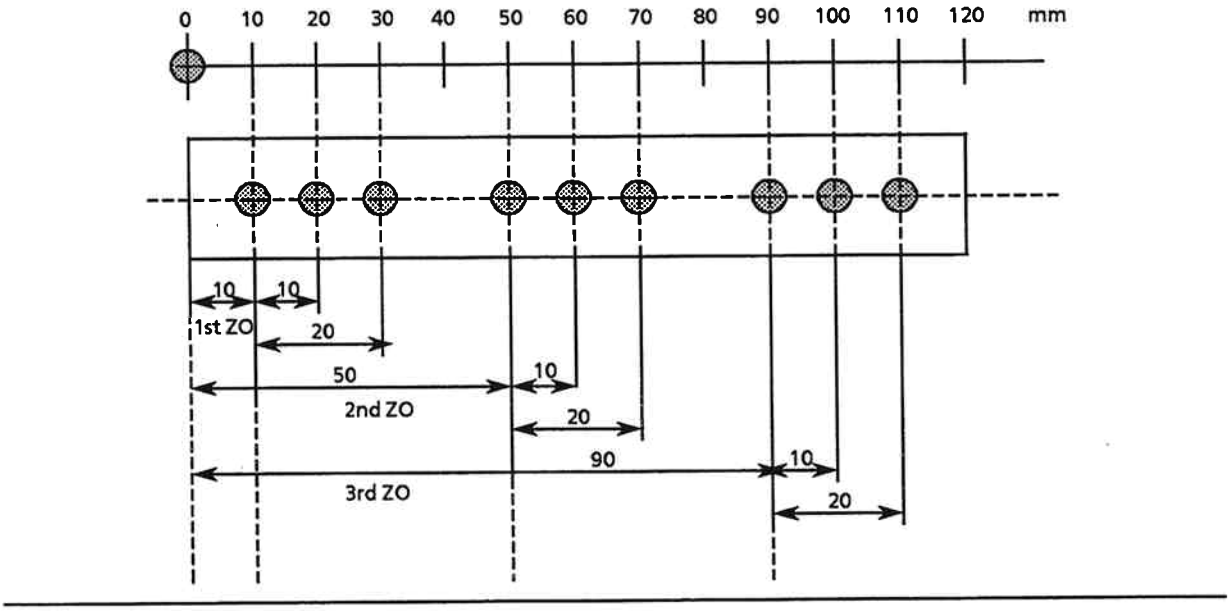


Figure 5-8. Using a Zero Offset

Zero offset (ZO)
A zero offset makes it possible to match the coordinate basic origin to different conditions.

You must enter four values ("0" is also allowed) in the machine data for zero offsets 1 to 4. These values need not be identical. Entries not within the traversing range are reported with an error message.

Also note that
- the software limit switches
- the reference point and
- the actual value

are recomputed when a zero offset is used. When you enter the data, remember that all coordinates must be within the permissible range (refer to the following example).

The zero offset values are available only to the programmable ZOs in traversing programs (see Section 5.4). If you want to specify another zero offset, you must use modes 12 and 15.

Example:
Table 5.3 contains absolute position values. The "Before" column shows the positions that were current prior to a ZO. A relative zero offset of - 400 mm renders the actual value, the software limit switches and the reference point more positive by 400. As you can see in Table 5-3, this measure puts the software end limit switch out of range.

Table 5-3. Coordinate Shift as Consequence of a Zero Offset

	Coordinates in mm	
	Before	After
Software limit switch (start)	-16000	-15600
Software limit switch (end)	32500	32900
Reference point	0	400
Actual value	200	600

Tool offset (TO)
The tool offset is a coordinate shift, and is used to compensate for tool wear.

The maximum value for a tool offset depends on the axis used. The value specified in the machine data can be called up from a traversing program only via G functions for positive or negative tool offsets (see Section 5.4).

Value range: ± 32767.999 mm
The sum of the coordinate values for
- software limit switches and
- tool offset

must be in the range ± 32767.999 mm.

Note:

Invocation of a tool offset does **not** result in a traversing movement.

Use mode 15 if you want to implement a tool offset other than the one defined in the machine data.

Following a tool offset, the coordinate system is displaced by the value of that tool offset, i. e. the values become **more positive** by the value of the tool offset.

You will find two detailed examples showing the use of tool offsets in the part of Section 5.3.15 that describes the tool offset mode.

Backlash compensation
"Play" in the drive system is referred to as backlash. On each reversal of the direction of movement, the backlash causes the motor to rotate without changing the position of the axis. Backlash outside the position control loop can be compensated. When the direction of movement is reversed, the IP 266 makes allowance for the backlash.

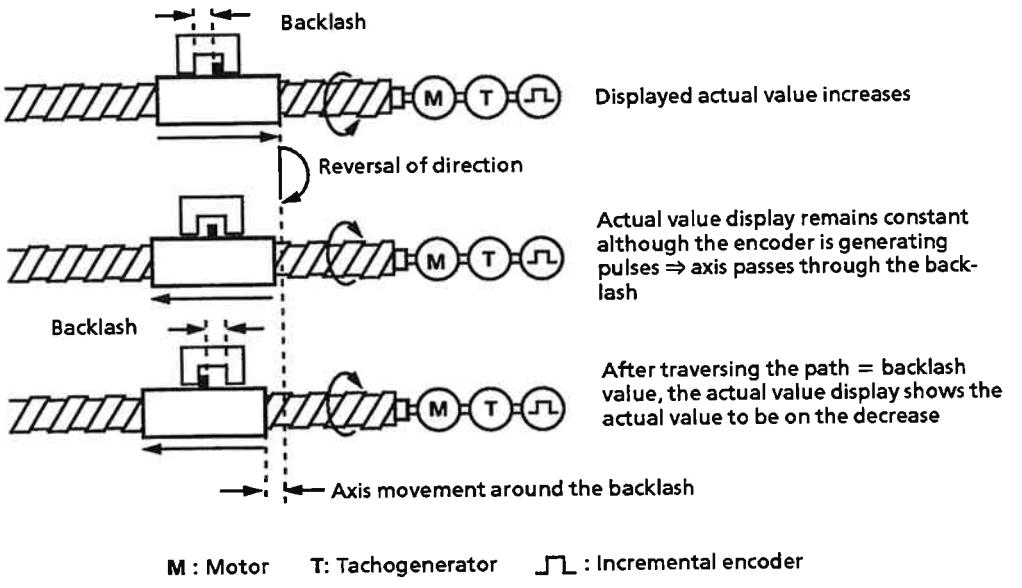


Figure 5-9. Backlash Outside the Control Loop (compensatible)

Conditions for correct operation:

- Positive mechanical coupling between drive and slide
  - when a distance > backlash value is traversed.

- Reference point has been approached
  - when the distance to zero mark recognition is > backlash value.

- Following a drive movement within the permissible play of the backlash (follow-up mode), the conditions for correct operation are no longer fulfilled. A positive mechanical coupling must be reestablished between the drive and the slide.

- Overswing can also result in loss of positive mechanical coupling. This is possible when the overswing movement caused the distance traversed to be less than the backlash. Overswing can be avoided by reducing the Kv factor.

5.1.8 Miscellaneous Parameters

Direction of the reference point approach
To enable exact reproducibility, the reference point must always be approached from the same direction. The direction is selected by specifying "forw" for forward or "rev" for reverse.

> **Note:**
>
> Specification of the direction is crucial to the reproducibility of the reference point (see Section 5.3.5).

PLC BCD-coded
You must enter "yes" in this field when you want to enter the positioning specification data in BCD format. Entries in BCD code must be in the range ±9 999.999 mm.

Actual value, distance to go and following error, when monitored, are also output in BCD code.

Polarity of the hardware limit switches
The hardware switches and the IP 266 "External Stop" may be designed as NO or NC contacts. You must enter the identifier for NO or NC in the machine data.

Enter "pos" to identify the switches as NO contact.
Enter "neg" to identify the switches as NC contacts.

IP STOP if CPU STOP
If you enter "YES", the operation in progress when the CPU stops is aborted.

5.2 Modes and How to Invoke Them

The IP 266 provides a large variety of options for positioning, coordinate shifting and positional corrections. These options are grouped under the term "modes".

The available modes can be divided into the two basic categories
- open-loop positioning and
- closed-loop positioning

Table 5-4 lists the modes belonging to each of these two categories.

Table 5-4. Positioning Modes with and without Position Control

Positioning Modes				
Without position control		With position control		
Output of a constant speed setpoint	**Setpoint output = 0 V + drift voltage**	**Approach to a specific target position; traversing a specific distance**	**Command-initiated forward/reverse travel**	**Bring coordinate system to a defined state**
Controlled jog	Follow-up mode	Increment mode absolute	Jog 1	Approach to reference point
		Increment mode relative	Jog 2	
		Automatic mode		
		Automatic single block mode		

In addition to the modes listed above, a number of information modes are also available. These include modes 71 to 73, which provide information on the status and position of the drive.

The table below provides an overview of all IP 266 modes and a section reference for each. You can call up these modes

- from the PLC's CPU via a STEP 5 program or
- from the programmer via the COM 266 software

An appropriate indication is given in the descriptions of those modes, which cannot be invoked on the programmer.

Table 5-5. Overview of Available Modes

Mode		Section
No	Description	
1	Jog 1	→ 5.3.1
2	Jog 2	→ 5.3.2
3	Controlled jog	→ 5.3.3
4	Follow-up	→ 5.3.4
5	Set/approach to ref. point	→ 5.3.5
6	Increment mode absolute	→ 5.3.6
7	Increment mode relative	→ 5.3.7
8	Automatic mode	→ 5.3.8
9	Automatic single block	→ 5.3.9
10	Enable teach-in mode	→ 5.3.10
11	Disable teach-in mode	→ 5.3.11
12	Zero offset absolute	→ 5.3.12
13	Zero offset relative	→ 5.3.13
14	Delete zero offset	→ 5.3.14
15	Enable tool offset	→ 5.3.15

Mode		Section
No	Description	
16	Disable tool offset	→ 5.3.16
17	Acknowledge error	→ 5.3.17
18	Enable drift compensation	→ 5.3.18
19	Disable drift compensation	→ 5.3.19
20	Transferring machine data	→ 5.3.20
26	EEPROM↔IP 266	→ 5.3.21
31	Unrestricted speed specification	→ 5.3.22
32	Reading out the unrestricted speed specification	→ 5.3.23
33	Disabling the monitors	→ 5.3.24
34	Enabling the monitors	→ 5.3.25
71	Read actual position	→ 5.3.26
72	Read following error	→ 5.3.26
73	Read distance to go	→ 5.3.26
99	Synchronize IP	→ 5.3.27

5.3 IP 266 Modes

A mode is invoked on the IP 266 by entering an operator command. An operator command comprises three elements: the mode, the parameters, and the keystroke representing the function.

When you select a mode, you choose a function. After entering the required parameters, you start the mode by choosing the function. Figure 5-10 shows the elements comprising an operator command. In the following sections, each mode description is preceded by a diagrammatic line showing the available options for the operator command for that mode.

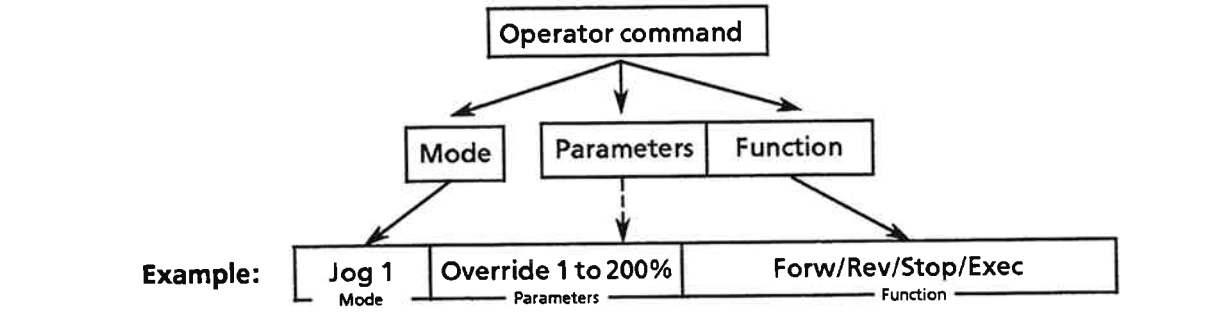
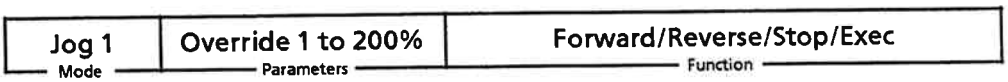


Figure 5-10. Format of an Operator Command

5.3.1 Jog 1 (Mode 1)



The drive can be positioned at a constant speed. The IP 266 uses jog speed 1 from the machine data for this purpose. Please remember that you must specify two speeds in the machine data for this mode, i. e. forward jog speeds 1 and reverse jog speeds 1. Forward speeds and reverse speeds need not be identical.

After selecting the mode, start the positioning operation by entering the function "Forward" or "Reverse".
In COM 266, the functions are actually keystrokes. Each function is allocated to a specific function key, and a function is "entered" by pressing the function key to which it is assigned.

Figure 5-11 illustrates a positioning operation in the "Jog 1" mode. "Forward" starts the positioning operation. "Stop" initiates a defined deceleration procedure. The "Reverse" function is executed as soon as the drive reaches zero speed, as it was issued while deceleration was still in progress.

A direct change from Forward to Reverse is permitted.

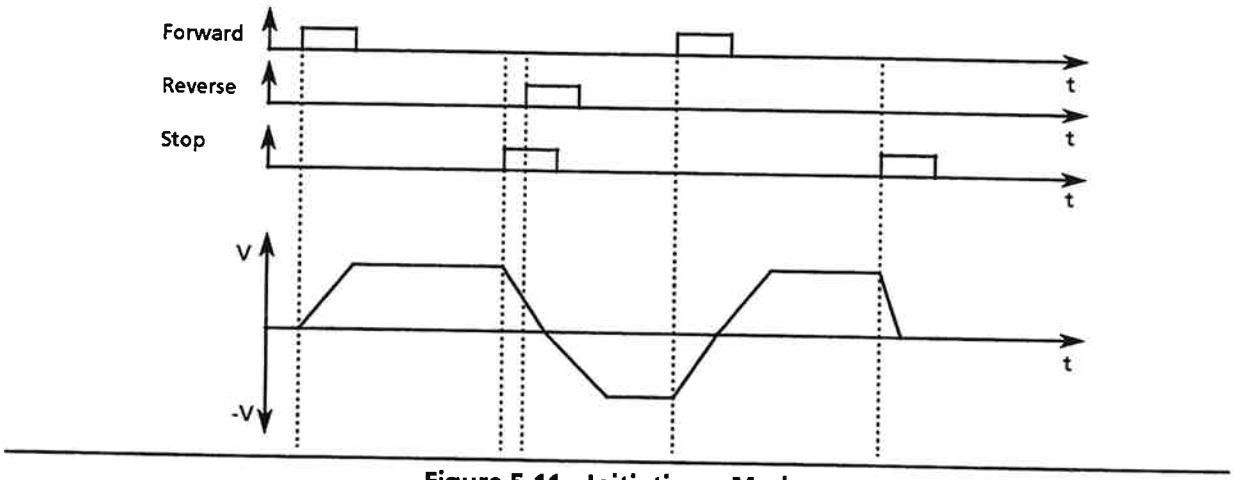


Figure 5-11. Initiating a Mode

The drive moves at 100% of the specified speed.
"Stop" initiates a defined deceleration procedure.

You can vary the speed with the Override factor. The IP 266 permits entry of an Override factor of from 1% to 200% of the specified speed.

> **Note:**
>
> Theoretically, an excessively high Override factor could result in the drive exceeding the maximum speed. In this case, the IP 266 positions at maximum speed and flags the discrepancy on the monitor's error line.

If you want to change the speed during travel, simply forward the appropriate Override factor to the IP 266.

- ▸ Change the Override factor in the COM screen form or in the output frame (PLC → IP 266).
- ▸ Press "Exec".

⇒ The drive accelerates or decelerates at a steady state to reach the new positioning speed. The IP 266 takes the
  - acceleration rate or
  - deceleration rate

  from the machine data.

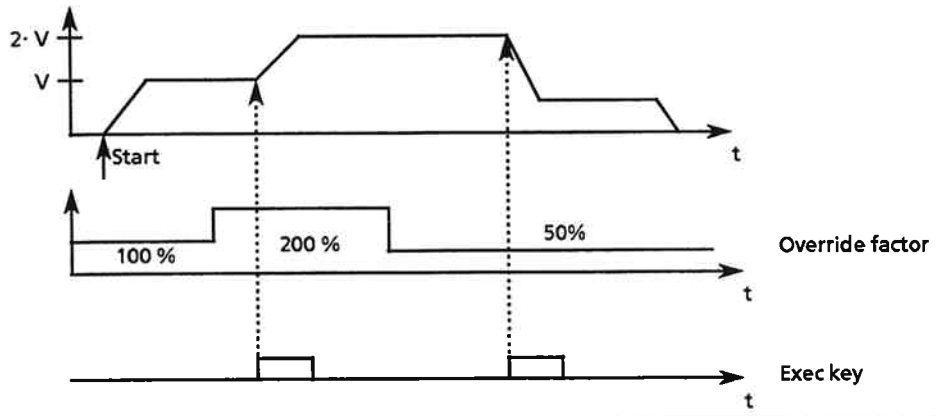
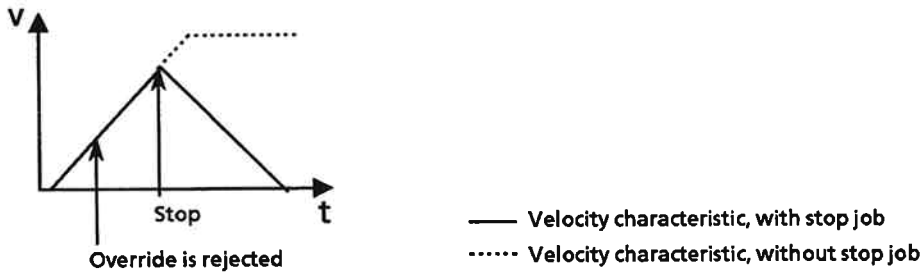


Figure 5-12. Controlling the Traversing Speed via the Override Factor

Override factor

A change in the override factor during an acceleration or deceleration phase is rejected. The job is aborted with the fault message F82 (Inadmissible order). Execution of the current job, however, is not affected.

A stop during an acceleration or deceleration phase, however, is executed immediately.



5.3.2 Jog 2 (Mode 2)

Jog 2 (Mode)	Override 1 to 200% (Parameters)	Forward/Reverse/Stop/Exec (Function)

In essence, the "Jog 2" mode is identical to the "Jog 1" mode. The machine data contains two speed values for this mode:

- Jog 2 forward speed
- Jog 2 reverse speed

The jog speeds for jog mode 1 and jog mode 2 need not be identical.

5.3.3 Jog under Open-Loop Control (Mode 3)

Jog under Op.-Loop Contol (Mode)	Override 1 to 200% (Parameters)	Forward/Reverse/Stop/Exec (Function)

In this mode, axis travel is **under open-loop control**. Computation of the setpoint position is disabled when this mode is started with

- "Forward" or
- "Reverse"

The setpoint position is now matched to the actual position. The result is a following error of zero. The setpoint position is matched at the speed defined in the machine data for Jog 2 mode. This value can be varied from 1 to 200% via the Override factor. The speed computed from the encoder signals is displayed on the programmer.

If you invoked mode 73 before starting Jog 2 mode, the distance to go is displayed.

Note:

The IP 266 needs correct data for the drive system (encoder, axis) to attain the speed displayed. Incorrect machine data will result in incorrect computation of the actual value.

If the power section is correctly calibrated, the speed displayed and the actual speed are identical.

The functions

- "Forward"
- "Reverse" and
- "Exec"

are the same in mode 1.

"Stop" decelerates the drive at the specified deceleration rate until it has reached zero speed. When the axis has reached zero speed, the position control loop is once again closed and the axis is positioned **under closed-loop control**.

5.3.4 Follow-Up Mode (Mode 4)

Like mode 3, mode 4 is a controlled mode.

▸ Invoke mode 4 with "Start". The IP 266 executes the following operations:
⇒ - Computing of the position setpoint is disabled
- The position setpoint is corrected to the actual position
- Actual-value acquisition remains enabled.

The speed controller is thus driven with a setpoint of 0 V ± drift compensation.
A drift compensation value is taken into account only when mode 18 was previously started.

You can adjust the position of the axis either
- manually after switching off the power supply for the power section
  or
- via an external speed setpoint.

The coordinate system is not affected. The speed controller can be reenabled at any time.

Note:

If your drive system is not free from backlash, care must be taken that the drive be adjusted by at least the value of the backlash, regardless of whether the adjustment is made manually or via an external speed setpoint, as only then can it be guaranteed that a positive mechanical coupling will be maintained after the adjustment has been made.

"Stop" terminates the mode. The axis returns to the closed-loop state.

Mode 4 is also enabled on a response from the IP 266's encoder monitor. In this case, a setpoint of 0 V is output. When you have rectified the error, stop mode 4. The controller is reenabled, as is the position control monitor.

5.3.5 Set/Approach Reference Point (Mode 5)

Reference point	Set/Approach	Start/Stop
Mode	Parameters	Function

This mode is used to synchronize the IP 266's pulse counter with the drive system.

Synchronization of drive and pulse counter is necessary
- to enable an approach to an absolute target position
- to enable evaluation of the software limit switches
- to invoke modes 6, 8, 9 and 10 and
- because the reference point is lost following power-up

When this mode is invoked, the IP 266 assigns the coordinate value specified under "reference coordinate" in the machine data to the axis position.

Note:

Zero offsets and tool offsets that were in force before the reference point was assigned are not affected.

The IP 266 provides two options for establishing a reference point:
- Approach reference point
- Set reference point

Approach reference point
When you configured the drive, you installed a reference point switch. The reference point switch must lie in the positioning range between the two hardware limit switches. This switch is required for the "Approach reference point" mode.

Note:

Hardware limit switches cannot be used as reference point switch.

Figure 5-13 illustrates the use of the various switches and their layout in a drive system.

From the instant at which a switch is actuated until the instant at which it is passed, the drive moves a specific distance. This distance, or path, is represented as the spatial extent of the switches. This extent is absolutely necessary for the correct functioning of the system. The drive must be so designed that it can be decelerated from the maximum speed without passing the switch.

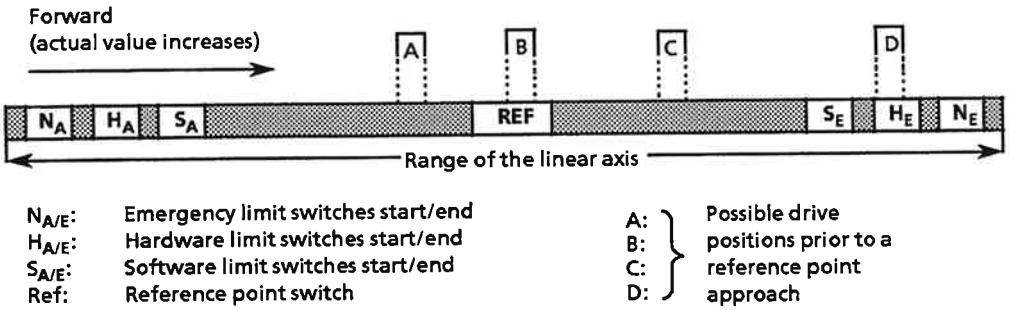


Figure 5-13. Drive Starting Positions for a Reference Point Approach

Before approaching a reference point, you must make a distinction between four different situations. The criteria for making this distinction are

- the position of the drive prior to the reference point approach (position A, B, C or D)
- the direction from which the reference point is approached

The four examples below describe a reference point approach in dependence on the starting position of the drive.
The prerequisites listed in Table 5-6 apply to all four examples.

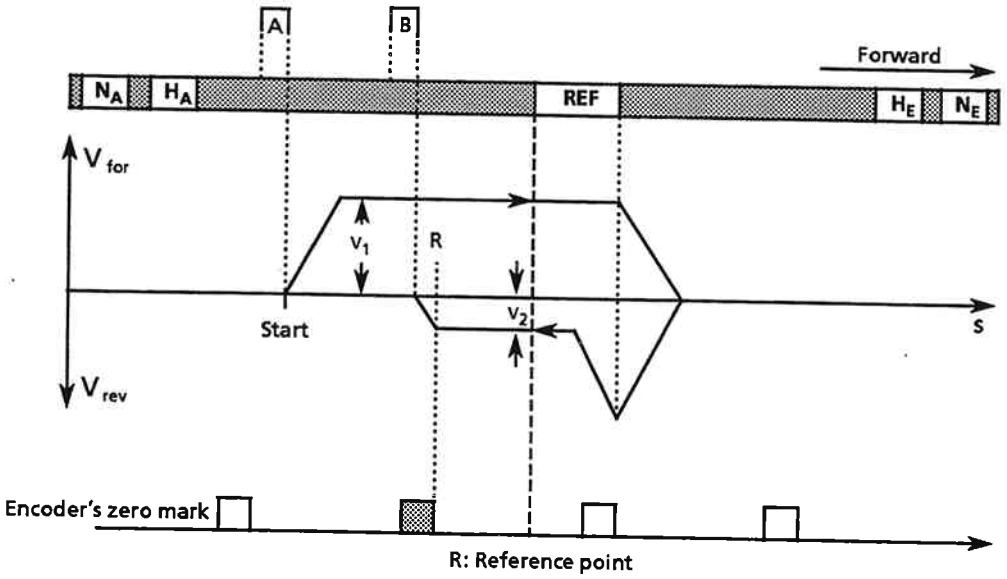
Table 5-6. Prerequisites for the Reference Point Approach (Examples A to D)

Machine Data	
Data item	Value/Specification
Direction of reference point approach	*Reverse*
Reference point approach speed 1	*2000 mm/min*
Reference point approach speed 2	*200 mm/min*
Reference point coordinate	*0.000 mm*

Example A: The drive is in front of the reference point switch.
Start the reference point approach with "Start". The drive then executes the following movements in succession:

1. First, the axis accelerates in a **forward direction**, the IP 266 accelerating it at the specified acceleration rate. The drive thus accelerates toward the reference point switch.
2. When reference point speed 1 has been reached, the drive continues at a constant speed.
3. The movement is decelerated when
   - the drive has reached the reference point switch and
   - this switch is once again opened.
4. When the drive has come to rest, the IP 266 changes the direction of the reference point approach (to **reverse**). The drive again accelerates until it reaches reference speed 1.
5. When the edge of the signal from the reference point switch goes to 1, the IP 266 decelerates the drive to reference speed 2.

6. An edge change from 1 to 0 in the signal from the reference point switch sets an internal Enable signal. When this signal is set, the IP 266 waits (while the drive is moving at reference speed 2) for the next zero mark pulse from the encoder. This signal is present only once during each encoder revolution. A change of the zero mark signal from 0 to 1 sets the reference point. The reference point coordinate specified in the machine data is assigned to this position. At the same time, the IP 266 decelerates the drive until it reaches zero speed. The actual value is detected and displayed.
   When the drive is at zero speed, the actual value is lower (i. e. more negative) than the reference point coordinate.



H_A/H_E: Hardware limit switches start/end
V_1: Reference speed 1
V_2: Reference speed 2

Position of the drive:
A: Prior to the reference point approach
B: After the reference point approach

Figure 5-14. Principle of the Reference Point Approach in Example A

Example B: The drive is positioned to the reference point switch

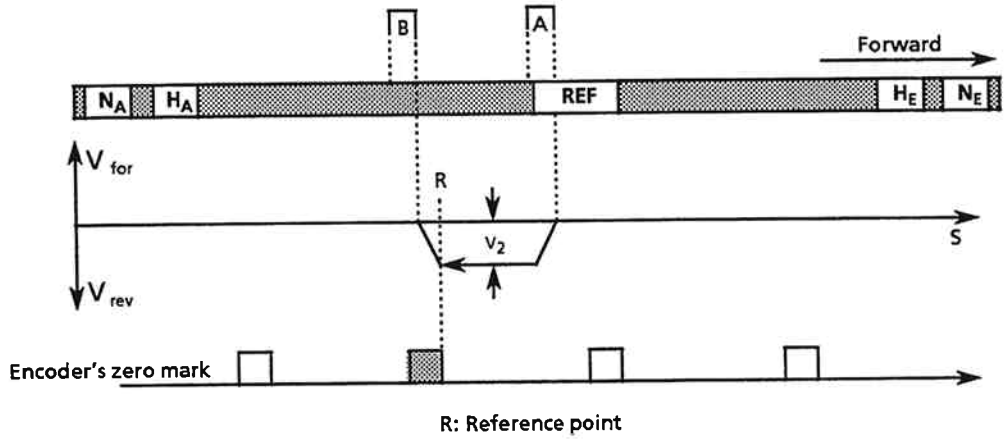


Figure 5-15. Reference Point Approach in Example B

This represents a special feature of the "Approach reference point" mode.

Start the reference point approach with "Start". The drive then executes the following movements:

1. The IP 266 accelerates the drive immediately in the specified direction until it reaches reference speed 2.
2. A change from 1 to 0 in the signal from the reference point switch sets an internal Enable signal. When this signal is set, the IP 266 waits for the next zero mark pulse from the encoder. A change of the zero mark signal from 0 to 1 sets the reference point. The reference point coordinate specified in the machine data is assigned to this position. At the same time, the IP 266 decelerates the drive to zero speed. The actual value is acquired and displayed. When the drive is at zero speed, the actual value is lower (i. e. more negative) than the reference point coordinate.

Example C: The drive is behind the reference point switch.

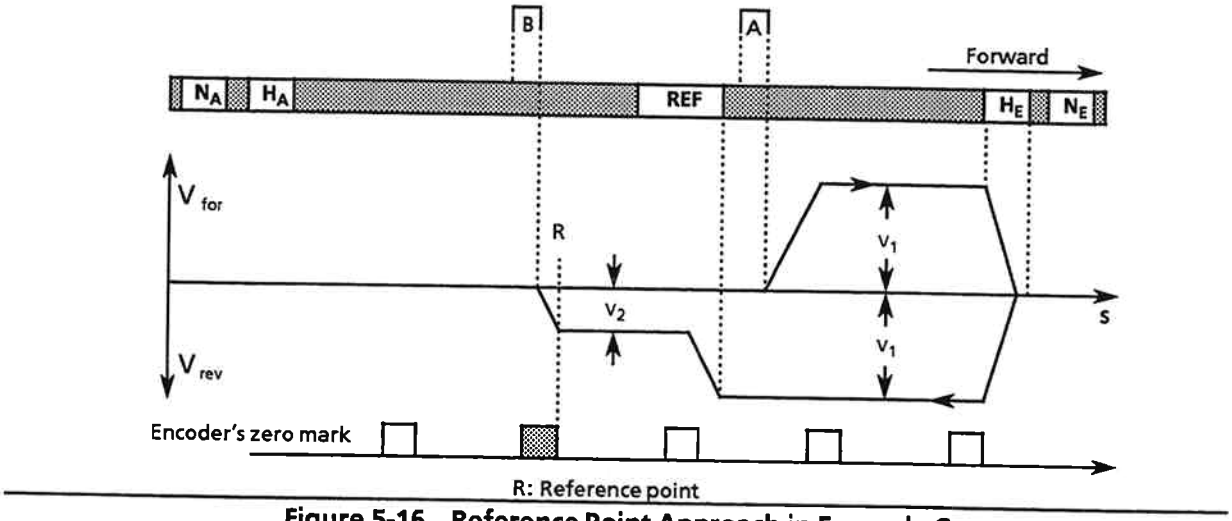


Figure 5-16. Reference Point Approach in Example C

Start the reference point approach with "Start". The drive then executes the following movements:

1. First, the IP 266 accelerates the axis in a **forward** direction at the specified acceleration rate. The drive is thus accelerated toward the hardware end limit switch.
2. When it has reached reference speed 1, the drive moves at constant speed.
3. When the limit switch is reached, the IP 266 decelerates the drive at the specified deceleration rate.
4. When the drive reaches zero speed, the IP 266 switches it into **reverse**, again accelerating it until it reaches reference speed 1.
5. When the edge of the signal from the reference point switch goes from 0 to 1, the IP 266 decelerates the drive to reference speed 2.
6. An edge change from 1 to 0 in the signal from the reference point switch sets an internal Enable signal. When this signal is set (the drive is moving at reference speed 2), the IP 266 waits for the next zero mark pulse from the encoder. A change from 0 to 1 in the zero mark signal sets the reference point. The reference point coordinate specified in the machine data is assigned to this position. At the same time, the IP 266 decelerates the drive to zero speed. The actual value is acquired and displayed. When the drive is at zero speed, the actual value is lower (i. e. more negative) than the reference point coordinate.

Example D: The drive is positioned to the hardware end limit switch.

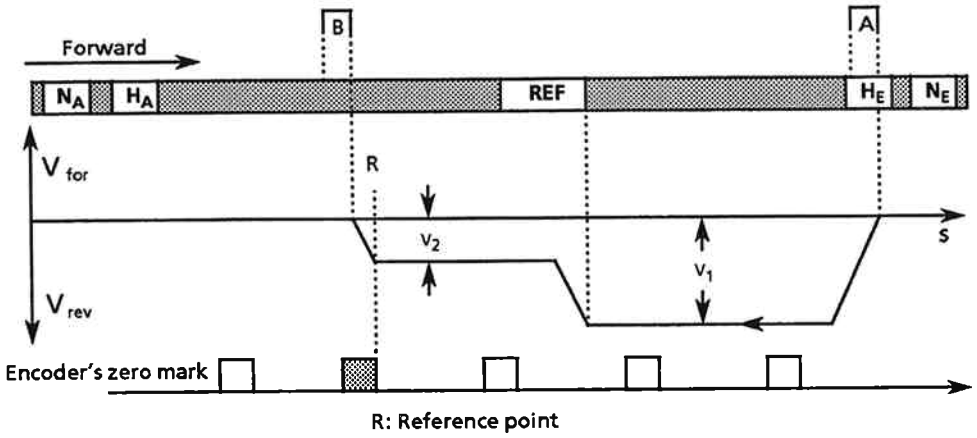


Figure 5-17. Reference Point Approach in Example D

Start the reference point approach with "Start". The drive then executes the following movements:

1. The IP 266 accelerates the axis in a **reverse** direction at the specified acceleration rate. The drive is thus moved toward the reference point switch.

2. When it has reached reference speed 1, the drive moves at a constant speed.

3. When the edge of the signal from the reference point switch goes from 0 to 1, the IP 266 decelerates the drive to reference speed 2.

4. An edge change from 1 to 0 in the signal from the reference point switch sets an internal Enable signal. When this signal is set (the drive is moving at reference speed 2), the IP 266 waits for the next zero mark pulse from the encoder. A change in the zero mark signal from 0 to 1 sets the reference point. The reference point coordinate specified in the machine data is assigned to this position. At the same time, the IP 266 decelerates the drive to zero speed. The actual value is acquired and displayed. When the drive is at zero speed, the actual value is lower (i. e. more negative) than the reference point coordinate.

Actual-value display following a reference point approach
The reference point is set when the position encoder's zero mark signal goes from 0 to 1. At the same time, the drive is decelerated. The drive moves a distance of X away from the reference point, the value of X depending on the specified deceleration rate and on reference speed 2. The distance X varies in dependence on the specified deceleration rates. If the drive is to come to rest exactly at the reference point, it must be set to this position with the "Increment mode absolute" following termination of the reference point approach.

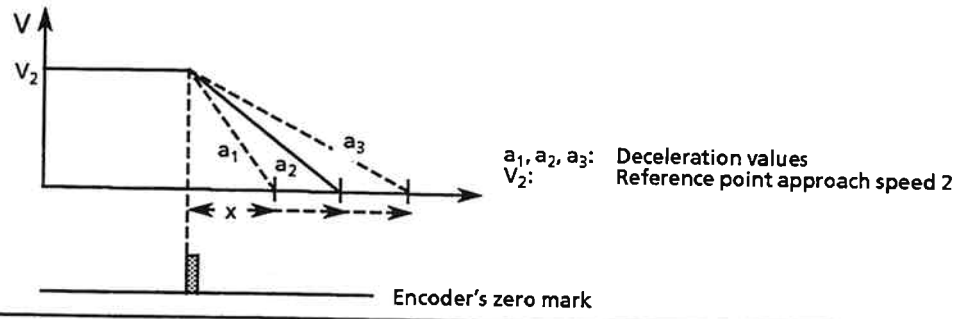


Figure 5-18. Deceleration at Different Deceleration Rates

Reproducibility of a reference point
In order to be able to use the traversing programs without any modifications even after an IP 266 power failure, it must be possible to reproduce the coordinate zero point exactly. This can be done when you make the next reference point approach from the same direction.

A change in the direction of reference point approach shifts the coordinate zero point. You can thus define two different zero points. The distance between them depends on the "width" of the reference point switch (see Figure 5-19).

Note:

If you replace an encoder, the old reference point **cannot** be reproduced because of a change in the position of the zero mark.

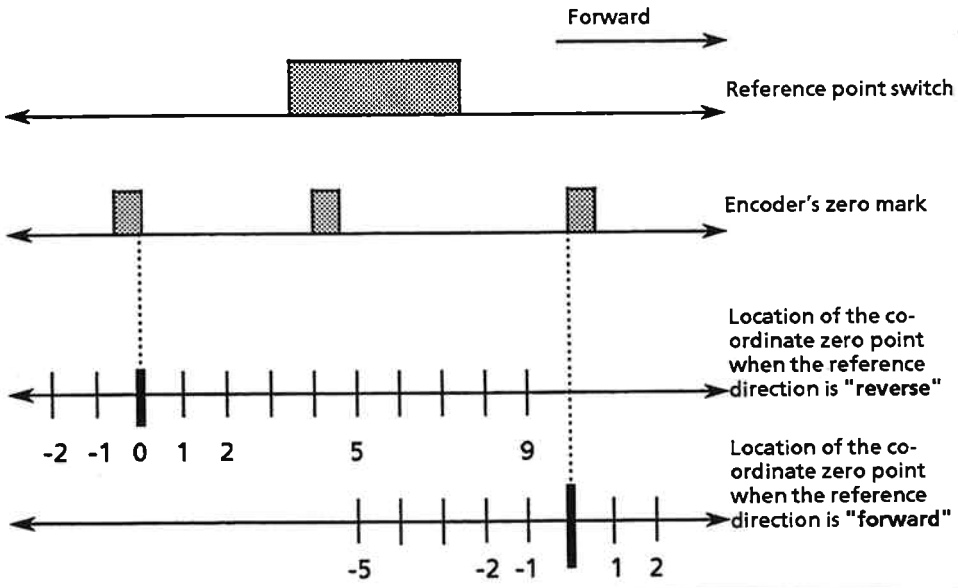


Figure 5-19. Reproducibility of the Reference Point for Reference Point Coordinate 0

Set reference point
Mode 5 allows you to set a reference point without moving the axis. To do so, select the "Set" function in mode 5. By invoking this function, you can set the reference point at an arbitrary axis position. The value specified in the machine data is then assigned to this position.
Tool offsets and zero offsets that existed before this mode was started will still be taken into account.

Note:

A reference point set with the "Set reference point" function is not reproducible.

Only when there is positive mechanical coupling can this function be used in drive systems that are not backlash-free.

The backlash is lost when the reference point is set. In this case, you must establish a positive mechanical coupling by traversing a distance greater than the value of the backlash.

5.3.6 Increment Mode Absolute (Mode 6)

Linear axis

Increment mode absolute	Override 1 to 200% Absolute target position	Start/Stop/Exec
Mode	Parameters	Function

This mode allows you to specify a target position in absolute coordinates. The target position is approached at incremental speed, without regard to the starting position of the drive. You can vary the incremental speed between 1 and 200% by specifying an Override factor.

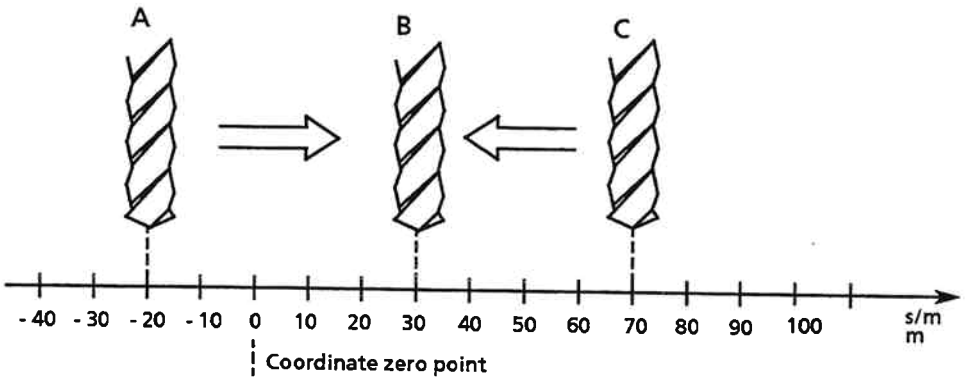


Figure 5-20. Absolute Target Specification in Mode 6

Before you can use this mode,
- the reference point must be set and
- the absolute target position specified must lie within the positioning range of the software limit switches.

Example for Figure 5-20
You start mode 6 with the following parameters:
- Override 100%
- Absolute target coordinate: 30 mm

Table 5-7. Drive Performance in Absolute Increment Mode

Prerequisites	Drive Response	Example (see Figure 5-20)
Starting point A must be located in front of defined absolute target position B	The drive moves **forward** to the specified target position at 100% incremental speed.	In the example, 50 mm **forward**
Starting point C must be located behind defined absolute target position B	The drive moves **in reverse** to the specified target position at 100% incremental speed.	In the example, 40 mm **in reverse**

Rotary axis

Increment mode absolute	Override 1 to 200% Absolute target position	Start/Stop/Forward/Reverse /Exec
Mode	Parameters	Function

The IP 266 responds differently to "Start" when the axis is rotary rather than linear. It computes the shortest possible path to the target position, and positions the axis accordingly.

If the distance is the same in both directions, the forward direction (clockwise) has priority. Backlash is not taken into account. If the axis is already at the target position, no movement is made, i. e. only the displacement of the object to be positioned is taken into account, not that of the motor.

The "FORWARD" and "REVERSE" functions can also be invoked in this mode.
The table below lists the permissible functions in absolute increment mode for both rotary and linear axes.

Table 5-8. Permissible Functions in "Absolute Increment Mode"

Function	Rotary axis	Linear axis
START	Approach to target over the shortest possible path	Approach to absolute target position
STOP	Exit mode	
FORWARD	Approach to target in forward direction (clockwise). If the axis is already at the target position, the entire range is traversed once.	—
REVERSE	Approach to target in reverse direction (counter-clockwise). If the axis is already at the target position, the entire range is traversed once.	—
EXEC	Change the speed via the Override factor when the axis is "traversing".	

5.3.7 Increment Mode Relative (Mode 7)

Increment mode relative	Override 1 to 200% Distance	Forward/Reverse/Stop/Exec
Mode	Parameters	Function

This mode differs from mode 6 primarily as regards specification of the target position; in this mode, you specify the target coordinate in relation to the current position of the drive.

As in mode 6, the incremental speed can be varied by specifying an Override factor.

Prerequisites when a reference point has been set:
The resulting target coordinate must lie between the two software limit switches.

When you use this mode without having set a reference point, the target position may lie anywhere within the range of the two hardware limit switches.

The positioning direction depends on
- the first function selected in this mode
  and
- the sign of the position specification

Table 5-9 shows how the direction of travel is determined.

Table 5-9. Determining the Direction of Travel in Relative Increment Mode

Sign of the position specification	Start function	Direction of travel
Positive	Forward	Forward
Negative	Forward	Reverse
Positive	Reverse	Reverse
Negative	Reverse	Forward

Example: Relative increment mode is to be invoked at starting positions A (-10 mm) and B (60 mm).

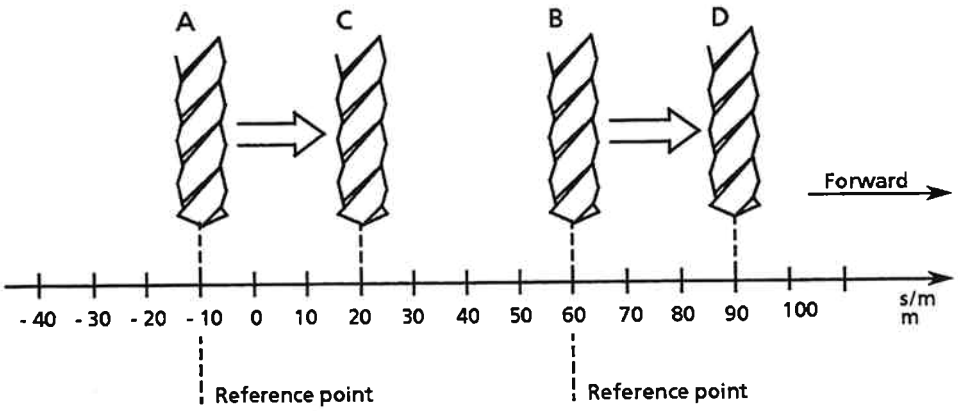


Figure 5-21. Relative Target Specification

- You start mode 7 with the parameters
  - Override 100%,
  - Distance: +30 mm

  and the "Forward" or "Reverse" function.

⇒ Based on the starting positions in Figure 5-21, the table below shows the resulting values:

Table 5-10. Using the 'Forward' Function in Mode 7

Travel	Starting position (absolute)	Distance	Target position (absolute)
A→C	-10 mm	+30 mm	+20 mm
B→D	+60 mm	+30 mm	+90 mm

5.3.8 Automatic Mode (Mode 8)

Automatic mode	Program number	Start/Stop
Mode	Parameters	Function

A traversing program (TP) is started in automatic mode. Before you can start a traversing program, you must write it and store it on the IP 266 (see Section 5-4). The program may contain

- positioning operations
- coordinate shifts
- corrections and
- dwells.

The IP 266 executes all programmed operations in succession. You run the program by invoking the Start function. Program execution always begins with the first block in the program.

The Stop function aborts the program. Any zero offsets invoked during program execution are retained, i. e. they are not reset. Zero offsets are reset only when the program executes in its entirety.

In automatic mode, enabled tool offsets are retained after the program terminates or is aborted.

If a traversing program processes a rotary axis, it is preset for traversing to the target position over the shortest possible path. Because the IP 266 itself computes the shortest path, and thus the direction of travel, you must be aware of the possible results of a flying change; if you have programmed a flying change, you must know in advance whether such a change is permissible or whether it will result in an error.

Note:

A machining program that was aborted with 'Stop' **cannot** be resumed at the point of interruption.

The remaining distance to go is retained until the next positioning operation.

Interruption of the traversing program via the "External Start Enable" signal is possible. If a positioning operation or dwell is currently in progress, it is completed prior to interruption of the program. When the signal is enabled, i. e. when the signal level is "1", the traversing program is resumed at the point of interruption.

5.3.9 Automatic Single Block (Mode 9)

Automatic single block	Program number	Start/Stop/Exec
Mode	Parameters	Function

Traversing programs written for mode 8 can be used without modification in mode 9. Before starting the mode, enter the number of the traversing program you want to execute. Start the mode by selecting the "Start" function.

The IP 266 interrupts program execution prior to every positioning operation or dwell. Start the next job with "Exec".

As in mode 8, an "External Start Enable" signal can interrupt the traversing program. If a positioning operation or dwell is in progress, it is completed prior to the interruption.

The IP then awaits the "Exec" command. When you have pressed "Exec", absence of the "External Start Enable" signal is flagged with an error message. When the signal is enabled, i. e. becomes "1", the traversing program is resumed at the point of interruption.

"Exec" is not permitted at this point, and would abort the traversing program.

Interruption points in a traversing program in single block mode
Table 5-11 lists the points at which a program is interrupted.

Table 5-11. Interruption Points in a Traversing Program in Mode 9

Special function	Sample block	Effect
Blocks containing a flying change (G10 function)	N10 **G10** X1000 F100 M10 N20 X2000 F500	Blocks are treated as a single block. **No** interruption takes place.
Blocks containing a flying change (G10 function) and a programmed stop (M00 function)	N10 **G10** X 1000 F100 **M00** N20 X2000 F500	Blocks are executed separately. The program is interrupted immediately preceding the X2000 function.
Blocks containing changes, corrections or offsets	N10 X100 F1000 M10 N20 **G56** X200 F1000 M11	The program is not aborted until function G56 has executed, i. e. just prior to the new positioning operation.

Blocks containing a programmed stop (function M00)
A programmed stop (M00) is suppressed in mode 9.
Exception: The block containing the M00 function also contains the G10 function.

5.3.10 Enable Teach-In (Mode 10)

Enable teach-in	Program number	Start
Mode	Parameters	Function

This mode is used to create a new traversing program for
- automatic mode
- automatic single block mode

Prerequisites to the use of this mode:
- The new traversing program must be assigned a number that has not already been assigned to another program.
- The IP 266's RAM must contain valid machine data.
- The reference point must be set.
- There must be enough room in the IP 266's RAM for the new program.

Enter a program number that is not yet on the module. A traversing program with this number is then generated on the IP 266.

Each block in the new program has the same structure, and comprises three elements:
- Block number
- Target position
- Speed

Block number
The blocks are numbered (see Section 5.4) in ascending order, beginning with N01. The third block thus has the number N03.

Target position
You can approach a target position in various modes. A new block is not written until you press "Exec" while the drive is at zero speed.

Table 5-12. Target Specification in Mode 10

Target position is specified	Function directive
by approaching it in mode 1 mode 2	The modes can be started by selecting one of the following functions: "Forward" "Reverse" "Start" "Exec" if you want to change the override **"Exec" while the axis is at zero speed writes the current actual position in a new block in the traversing program.**
by entering the coordinate in mode 6 mode 7	

Speed
You can specify a new target position in modes 1, 2/3, 6 and 7. This allows positioning to take place at the speeds specified in the machine data. You can vary these speeds via an Override factor, thus enabling extremely exact positioning.

Incremental speed 100% is always entered for each traversing program block generated in teach-in mode.
The figure below illustrates the use of the various speeds.

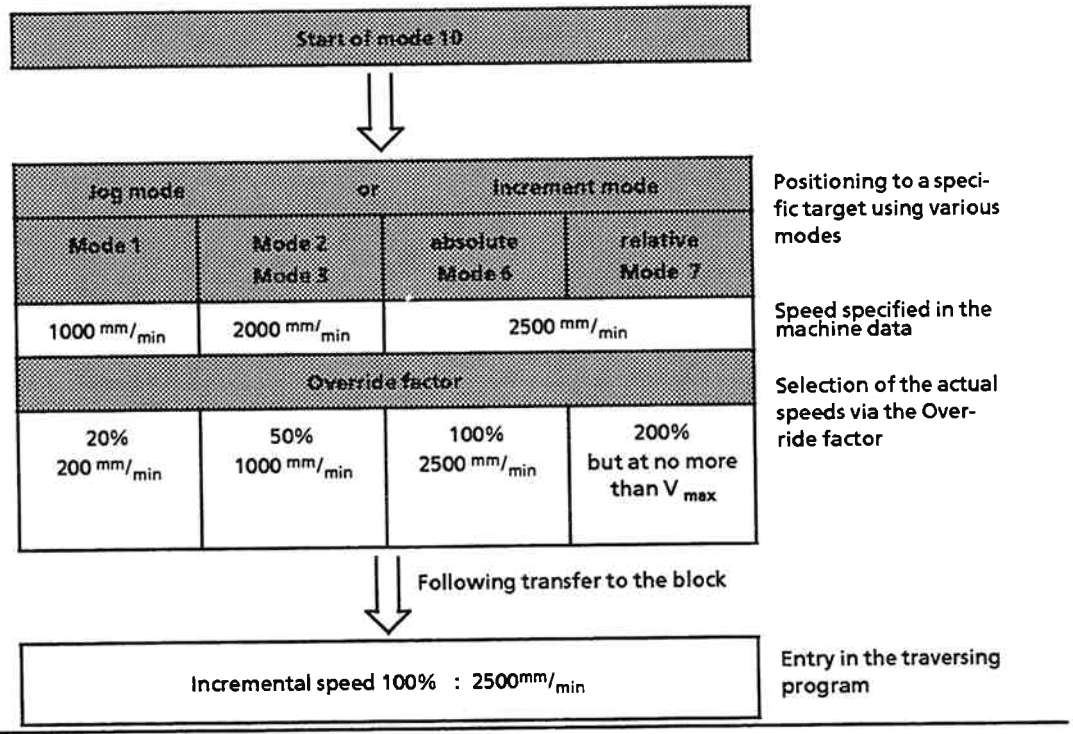


Figure 5-22. The Use of Speeds in Mode 10

Exception:
An error occurs in the position control loop in "Teach-in" mode. In this case, the IP 266 starts mode 4 on its own initiative.

You must then carry out the following steps:
- Terminate mode 4 by selecting the "Stop" function
- Terminate the "Teach-in" mode with mode 11

Example:
Generating a new traversing program in "Teach-in" mode:

The table below lists the actions you must take. Start at the top of the table and work down. The entries in the "Axis status" column indicate the state of the axis after the relevant key has been pressed.

Table 5-13. Generating a New Traversing Program in Mode 10

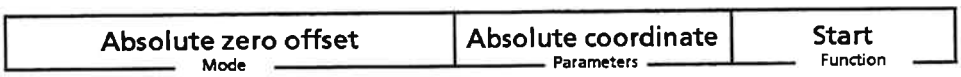
Mode and parameters	Press function key for	Effect	Axis status	Axis position
Mode 10 Prog. no. 7	Start	Program 7 is generated on the module	Stopped	Arbitrary
Mode 1 Override 20%	Forward	Move axis **forward** at 20% of jog speed 1	Travers-ing	Variable in accordance with movement
Mode 1 Override 50%	Exec	Change the speed to 50% of jog speed 1	Travers-ing	Variable
Mode 1	Stop	Decelerate	Travers-ing	Variable
		Zero speed	Stopped	E.g. 1258.250 mm
Mode 1	Exec	Store as block N01 X1258.250 F2500	Stopped	1258.250 mm
Mode 6 Abs. target pos. 3000 mm	Start	Move to absolute target position	Travers-ing	Variable
		Decelerate at position 3000 mm	Stopped	3000 mm
Mode 6	Exec	Store as block 2 N02 X3000 F2500	Stopped	3000 mm

5.3.11 Disable Teach-In (Mode 11)

This mode disables teach-in (mode 10).

Prerequisites:
Mandatory: Mode 10 was started.
Recommended: The creation of positioning blocks in mode 10.
End block Nnn M02 is entered in the machining program. nn is the block number. The value of Nnn depends on the current length of the traversing program.

5.3.12 Absolute Zero Offset (ZO) (Mode 12)



A ZO is used to assign new coordinates to a drive system. A ZO transforms all coordinates for
- the reference point and
- the software limit switches

and checks them for validity. No reference point need be set when this mode is invoked.
An "Absolute zero offset" assigns the value of the "Absolute coordinate" parameter to the actual value. This value is referred to in the following as ZO, or zero offset.

$$Actval_{new} = ZO$$

The zero point is offset by the value

$$ZO - Actval_{old}$$

The "Invalid position specification" error message is displayed if the maximum range is exceeded.

Note:

If mode 12 is restarted, the old ZO is replaced by the new ZO.

The IP 266 also provides other options for specifying a zero offset. The available options are listed in Table 5-14.

Table 5-14. IP 266 Zero Offset Options

ZO	Mode	Traversing program	Effect
absolute	12		Assigns a coordinate value to the current actual position. This coordinate value is displayed on the programmer as the new actual position.
relative	13		Offsets a coordinate value by a specifiable value
		G54 to G57	Offset in a traversing program by the values specified in the machine data. **These offsets are reset when the traversing program is exited.**

Once set, a zero offset is retained until
- it is overwritten by a new value
- reset via mode 14
  or
- the module's power supply is switched off.

Note the following when specifying a zero offset:

Negative offset:

$$-\text{Offset} \leq 32767.999 - |\text{Software end limit switch}|$$

Positive offset:

$$\text{Offset} \leq 32767.999 - |\text{Software start limit switch}|$$

Example: The drive is at the absolute position 50 mm. This position is to be offset in succession by 400 mm, -200 mm and 0 mm.

- Select mode 12.
- Enter the coordinate value for the new actual position.
- Start the mode with the "Start" function.
- Repeat the sequence for each zero offset.

⇒ The coordinate system must "respond" as shown in Figure 5-23. You can control the response by viewing the actual-value displays.

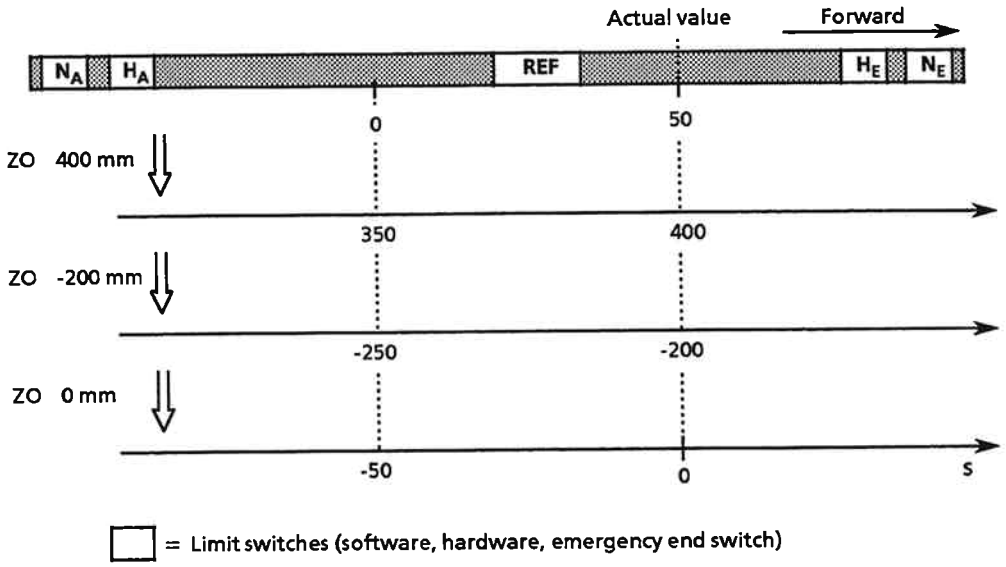


Figure 5-23. Zero Offset in Mode 12

Rotary axis:
When using a rotary axis, you may specify an absolute zero offset value outside the boundaries of the positioning range.

Example: A continuous belt has a positioning range of 0 to 200 mm. The current actual position is 150 mm.

An absolute zero offset of 300 mm changes the coordinate system
⇒ The current actual position is now 300 mm. The positioning range starts at 150 mm and the end of the positioning range is 350 mm.

The coordinate system was thus offset by the value

$$ZO_{abs} - Actval_{old}$$

From this point on, all absolute target specifications must lie within the new positioning range limits.

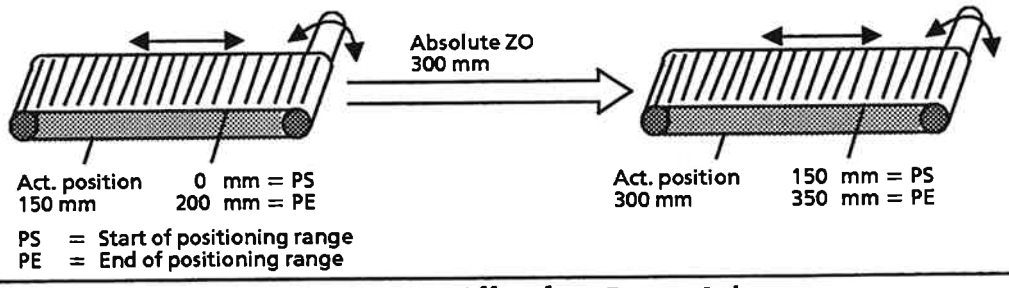


Figure 5-24. Zero Offset for a Rotary Axis

You will find an overview of all zero offsets in those portions of Section 5.4 which deal with G functions G53 to G57.

5.3.13 Relative Zero Offset (ZO) (Mode 13)

Relative zero offset	Value	Forward/Reverse
Mode	Parameters	Function

In contrast to mode 12, this mode allows you to specify the direction of the offset by selecting the "Forward" or "Reverse" function. You can also, of course, specify the offset direction by signing the offset value.
This mode does not require that a reference point be set.

The true direction of a zero offset is determined by
- the sign of the offset value
  and
- the selected function.

Each time this mode is started, the zero offset is summated as shown in Figure 5-15.

A zero offset can be reset only via mode 14 or by "power off".

Note:

An absolute zero offset overwrites a relative zero offset.

Table 5-15. Coordinate Changes Produced by a Zero Offset

Sign of the value	Start function	Coordinates become
Positive	Forward	more negative
Negative	Forward	more positive
Positive	Reverse	more positive
Negative	Reverse	more negative

The new actual value thus computes to
- $Actval_{new} = Actval_{old}$ - ZO when the direction is "Forward"
- $Actval_{new} = Actval_{old}$ + ZO when the direction is "Reverse"

Example: The drive is at the absolute position + 150 mm. Zero offsets of 300 mm, - 200 mm, - 150 mm and 50 mm are to be carried out in succession.
- ▸ Select mode 13.
- ▸ Enter the value for the offset, including the sign.
- ▸ Start the mode with the "Forward" or "Reverse" function. The function specifies the direction of the offset.
- ▸ Repeat the sequence for each of the zero offsets.
- ⇒ The coordinate system must respond as shown in Figure 5-25.

Note:

If you want to start the mode with the "Reverse" function, you must invert the sign when you enter the offset value.

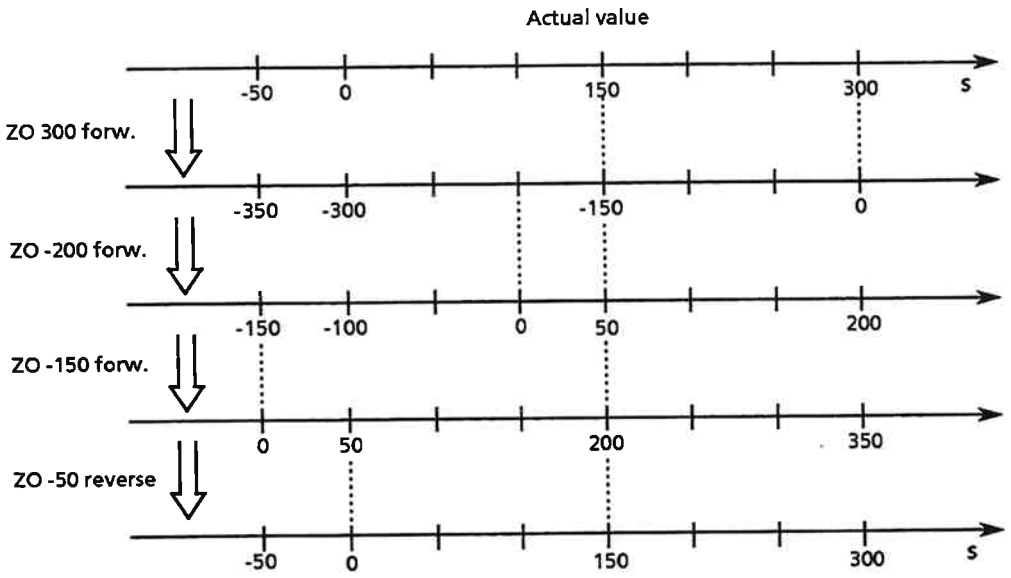
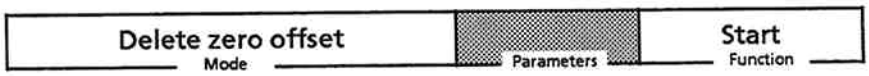


Figure 5-25. Relative Zero Offset with Different Values

5.3.14 Delete Zero Offset (ZO) (Mode 14)



This mode deletes (resets) all zero offsets that were set

- via mode 12,
- via mode 13 and
- via G functions (in prematurely aborted traversing programs).

5.3.15 Enable Tool Offset (TO) (Mode 15)

Enable tool offset	Offset	Forward/Reverse
Mode	Parameters	Function

This mode is used to compensate for changes in the tool length caused e. g. by tool wear.

Prerequisites for a tool offset:
- Valid machine data on the IP 266
- The offset value must lie within the maximum range.

This mode does not require a reference point.

The direction of the tool offset is determined by
- the sign of the offset value and
- the Start function ("Forward" or "Reverse")

Table 5-16. Coordinate Changes Produced by a Tool Offset

Sign of the value	Start function	Coordinates become
Positive	Forward	more positive
Negative	Forward	more negative
Positive	Reverse	more negative
Negative	Reverse	more positive

Following a tool offset, the position of the new tool tip is always displayed as actual position. The tool offset is taken into account when a target position is specified.

The range of the software limit switches is recomputed following a tool offset.

Use the following formulas as basis for specification of a tool offset:

In a negative direction:

$$-\text{Tool offset} \leq 32767.999 - |\text{Software end limit switch}|$$

In a positive direction:

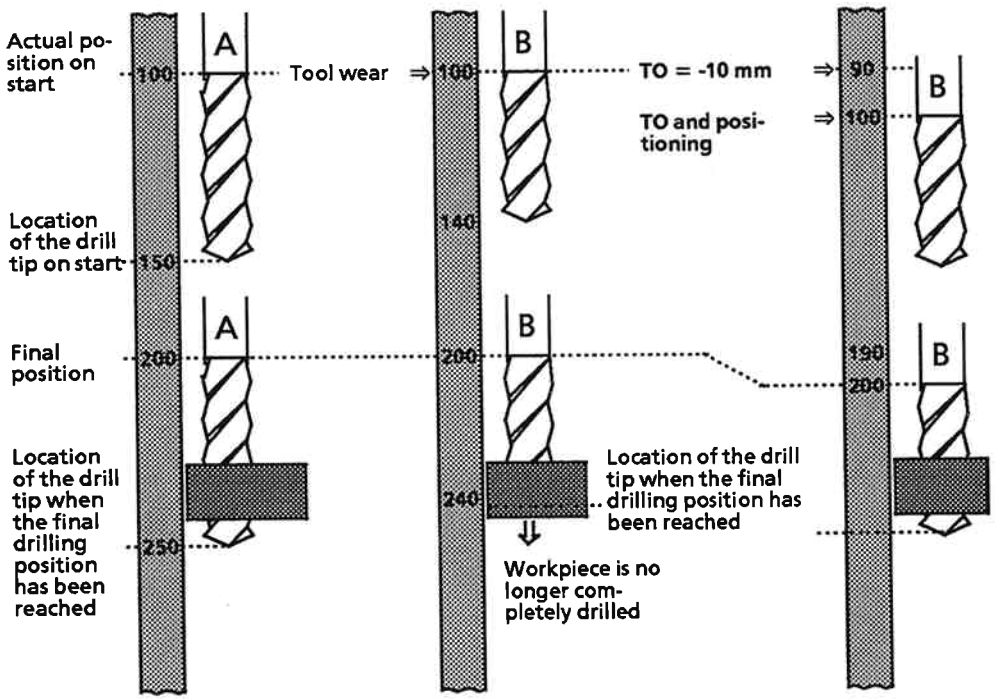
$$\text{Tool offset} \leq 32767.999 - |\text{Software start limit switch}|$$

The IP 266 does not execute a tool offset outside the permissible range limits.

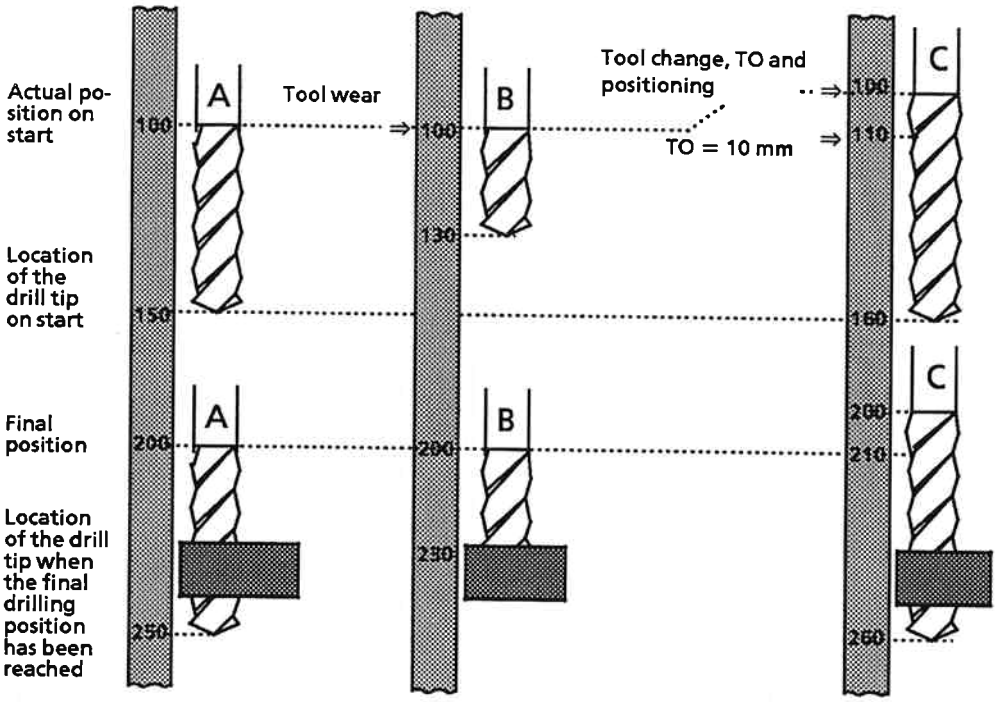
Example: Tool offset with mode 15
A drilling program used to drill a hole 15 mm in depth is to carry out the following steps:

1. Move the drill to the start position
2. Switch on the drill
3. Drill feed 15 mm
4. Return drill to the drilling position
5. Switch off the drill
6. Move the drill to the start position

The longer the drill is used, the more the drill depth decreases. When the drill reaches a length of 40 mm, it can no longer drill a complete hole. The drill tip remains in the workpiece. A tool offset shifts the coordinates. After being set to the starting position (100), the drill can once again drill a complete hole.



Example: Tool change and TO
When the tool has reached a length at which a tool offset is no longer possible, it must be replaced. The new tool is 10 mm too long. This can be compensated for via a tool offset, thus fulfilling the prerequisites for the automatic drilling sequence.



Example: The traversing range of a linear axis lies between the software limit switches; a reference point has been set.
Software start limit switch: - 500 mm
Software end limit switch: 700 mm
Traversing range is from - 500 mm to 700 mm.

Following a tool offset of 100 mm in a forward direction, these limits change as follows:
Software start limit switch: - 400 mm
Software end limit switch: 800 mm
The new range limits must be taken into account when specifying absolute target positions.

You will find an overview of all TO options in Section 5.4.2 under the heading "G Functions".

Rotary axis
The tool offset value must always be less than the difference between the
end of the traversing range and **the start of the traversing range.**
If the value is too high, it is rejected and an error message displayed.

A tool offset value that is within the permissible range modifies the actual position by the tool offset value. This does **not** affect the traversing range, which maintains its original range limits.

Example:

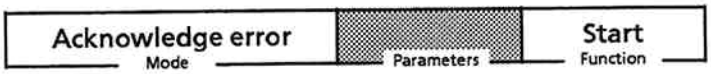
Traversing range prior to the TO	Traversing range after a TO of 30°
0 to 360°	0 to 360°

5.3.16 Disable Tool Offset (TO) (Mode 16)

This mode resets all tool offsets that were set via
- mode 15 or
- G functions in the traversing programs

Mode 16 cancels all tool offsets, i. e. you cannot use this mode to revoke the tool offset that was set via mode 15 while retaining the tool offset that was set via G functions.

5.3.17 Acknowledge Error (Mode 17)



Errors occurring during operation or during IP 266 start-up may have a number of different causes, such as
- operator input error
- external event (such as tripping of a limit switch)
- incomplete installation (e. g. machine data not complete)
- errors in machine data

Mode 17 is used to acknowledge an error.
Aside from mode 17, you can acknowledge an error only by starting another mode.
You cannot acknowledge an error by invoking an info (i. e. monitoring) mode.

5.3.18 Enable Drift Compensation (Mode 18)

Enable drift compensation	Parameters	Start
Mode		Function

Prerequisite to correct operation of the IP 266 is a properly calibrated power section (see Table 5-17).

Table 5-17. Data for Calibrating the Power Section

Power section input	The motor
+10 V	rotates in the forward direction at the rated speed
- 10 V	rotates in the reverse direction at the rated speed
±0 V	is at zero speed

These conditions must be regarded as ideal conditions, and cannot be attained during operation. Drift may occur even in well-calibrated power sections due to

- tolerances in the power electronics components and
- temperature drift

You can use mode 18 to compensate for such a drift.

Prerequisites:

- The axis must be at rest ('finished' status)
- The position control loop must be closed

Drift compensation:

- ▸ Select mode 18
- ▸ Start mode 18 with the "Start" function.

The IP 266 now monitors the following error for approximately 4 seconds. The following error corresponds to the drift in the power electronics. The IP 266 then computes a voltage value proportional to the following error as setpoint speed. When mode 18 is exited, this constant voltage is continually superimposed on the position controller's setpoint speed.
An "External Stop" does not abort this mode.

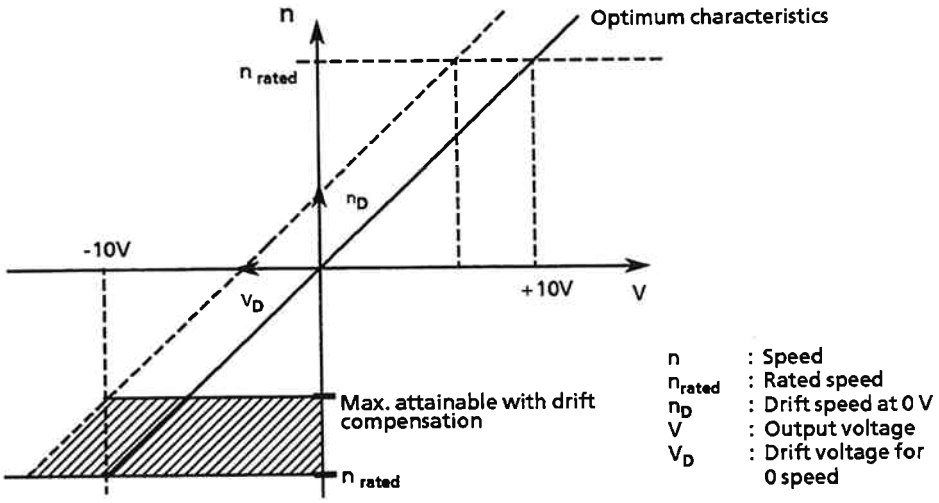


Figure 5-26. Voltage - Speed Characteristic with Drift Compensation

> **Warning**
>
> Serious errors disable the IP and produce a setpoint of 0 V without drift compensation.
> Serious errors are: watchdog errors (internal errors)
> resets
> The drive moves if there is drift.

The graphic shows that it is no longer possible to cover the full speed range. A portion of the high negative speed range can no longer be used.

If you were now to execute a positioning operation at a speed within this range, the following error would continually increase. Figure 5-27 illustrates this more clearly.

If the following error exceeds the specified maximum value, the IP 266 aborts the positioning operation currently in progress and outputs an error message.

Movement with V max. → increase in the following error

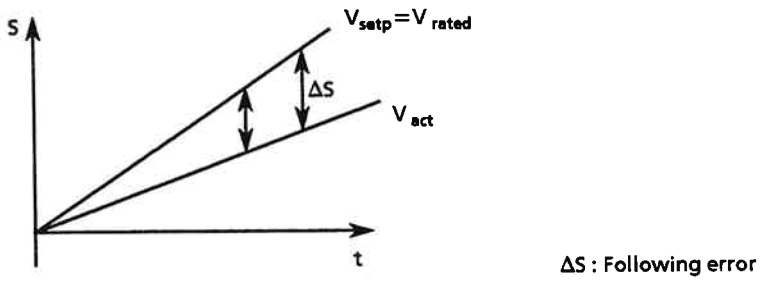


Figure 5-27. Erroneous Following Error Characteristic in Conjunction with Drift Compensation

Following modification of the machine data and "Power Off", the drift compensation voltage, if any, is disabled. Mode 18 must be restarted in order to determine the required compensation voltage.

5.3.19 Disable Drift Compensation (Mode 19)

With mode 19, you can disable the drift compensation enabled via mode 18. The compensation voltage is set back to 0 V.

Warning

If there is drift, there will be movement in your drive system, as the compensation voltage needed to counteract the drift is no longer available.

5.3.20 Transferring Machine Data (Mode 20)

This mode enables you to change all 36 values of the machine data of the IP 266. This allows you to change the parameterization of the IP 266 without using COM 266. For this purpose, you can load the parameters from previously prepared data blocks.

Note:

Machine data can only be transferred when the axis is at zero speed.
On transfer of a machine data item, the entire machine data set is re-interpreted and checked for errors. The function signal (FUM) is briefly revoked during this process.
After a machine data item has been transferred, any active shifts and compensating values on the module are deleted.

The synchronization (reference point) remains in force during transfer of machine data. The machine data items "Travel per encoder revolution" (No. 9) and "Pulses per encoder revolution" (No. 19) are exceptions to this.

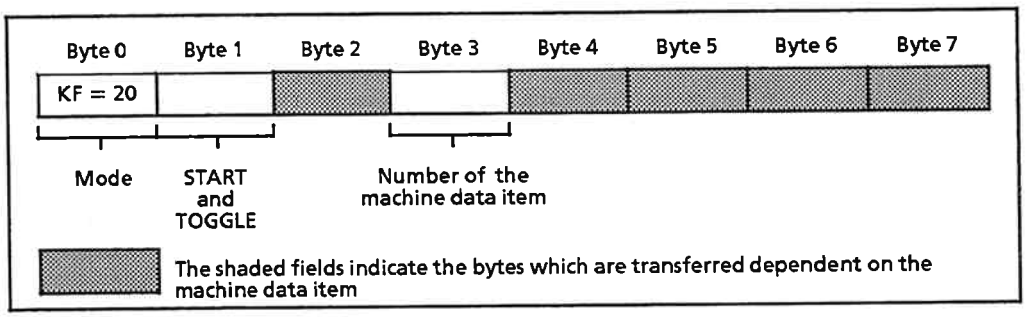
The machine data is transferred to the RAM of the IP 266, i.e. these values are lost at "Power off". On "Power on", the data in the EEPROM is loaded again.
You can, of course, store the new data in the EEPROM with mode 26.

Caution

The machine data is transferred from RAM to EEPROM for backup purposes only. If the machine data for your application constantly varies, it is inconvenient to always save this data direct on the EEPROM since the sum of EEPROM write cycles is limited to 10,000 .

One machine data item per data cycle can be transferred to the IP 266 over the 8-byte long output frame. The individual bytes have different meanings depending on the data.

The output frame has the following basic structure for this mode:



Byte 0 - Operating mode
Specify the number of the mode in this byte. Enter KF = 20 for mode 20.

Byte 1 - The start condition
Set the start condition in bit 0 with the value "1" and the TOGGLE function as Execute bit in bit 7 (→ Kap. 7.1.2).

Byte 3 - Number of the machine data item
You can preselect the machine data item to be transferred by specifying a value in KF format in the range 1 to 36.
The IP 266 checks during transfer that the parameter values have been specified correctly. If they are outside the permissible range, the IP 266 outputs an error message.
The following tables show the number assignments, the data descriptions and the arrangement of the parameters in the individual bytes.

All unnamed bytes are not significant for the byte in question and can assume any values, i.e.
- the values for machine data 1 to 27 are entered in bytes 4 to 7,
- the value for machine data item 28 is entered in bytes 4 to 5 and
- the settings for machine data 29 to 36 are entered in byte 2.

Table 5-18. Machine Data with Parameters Entered in Bytes 4 to 7

Number	Description	Permissible Data Range	Byte 4, Byte 5	Byte 6, Byte 7
1	Maximum deceleration	10 to 9999	10 to 9999	0
2	Acceleration forward			
3	Deceleration forward			
4	Acceleration revers			
5	Deceleration revers			
6	Gain factor	0.1 to 99.9	Places before the point 0 to 99	Places after the point 0/1 to 9
7	Maximum following error	0.001 to 99.999	0 to 99	0/1 to 999
8	Standstill monitor	0.001 to 64.999	0 to 64	0/1 to 999
9	Distance per encoder revolution	0.001 to 400.000	0 to 400	0/1 to 999
10	Backlash compensation	0.000 to 64.999	0 to 64	0 to 999
11	Zero offset 1	-32767.999 to +32767.999	-32767 to +32767	0 to 999
12	Zero offset 2			
13	Zero offset 3			
14	Zero offset 4			
15	Tool length offset	-32767.999 to +32767.999	Places before the point -32767 to +32767	Places after the point 0 to 999
16	Reference point coordinate			
17	Software lower limit			
18	Software upper limit			
19	Pulses per encoder revolution	1 to 65000	0 to 65	0/1 to 999
20	Maximum speed			
21	Jog speed 1 forward			
22	Jog speed 1 backward			
23	Jog speed 2 forward			
24	Jog speed 2 backward			
25	Incremental speed			
26	Reference speed 1			
27	Reference speed 2			
28	Module number	1 to 99	1 to 99	----------

Note:

The "Module number" must contain the number previously transferred to the module with COM 266.

Table 5-19 shows machine data 29 to 36. The parameter values of this data are entered in byte 2 and contain information for enabling or disabling specific statuses on the module.

Table 5-19. Machine Data with Parameters Entered in Byte 2

Number	Description	Permissible Data Range in Byte 2
29	meas. system	1 = metric, 2 =inch, 3 =degree
30	Axis type	0 =linear axis, 1 = rotary axis
31	Encoder type	0 = 5 V, 1 = 24 V
32	Reference direction	0 =forward, 1 =backward
33	PLC BCD-coded	0 =yes, 1 =no
34	Polarity of the HW limit switches	0 = positive, 1 = negative
35	IP Stop if CPU Stop	0 =yes, 1 =no
36	Following error monitoring	0 =on, 1 =of

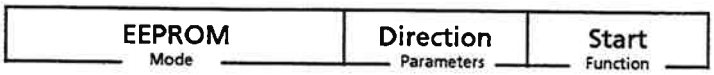
Note:

If "BCD = yes" is set by machine data number 33, this is not significant for modes 20, 31 and 32. All data transferred to the IP 266 must be in binary format.

Different limit values when specifying data in bytes 6/7
The values "0" or "0.000" must not be specified for machine data Nos. 6 to 9 and 19 to 27.
Division of a machine data item into two data words results in different limits for the inputs in byte 6/7 depending on the value specified. This is represented in the tables, for example, by the entry 0/1. "0" is permissible if bytes 4 and 5 contain a value not equal to "0".

Actual value characteristics as affected by specification of the machine data
If a reference point has not been set, the actual value coordinates will not change with the transfer of the machine data.
The machine data items "Travel per encoder revolution" and "Pulses per encoder revolution" are an exception to this.
When this machine data is transferred, the actual value is adapted to the current specification.

5.3.21 EEPROM (Mode 26)



You can use this mode to transfer data from the IP 266's RAM to EEPROM or from EEPROM to the IP's RAM.

Mode 26 always transfers all available data from the source to the destination, i. e. the machine data and all traversing programs.

> **Note:**
>
> This mode can be invoked only in a STEP 5 program (see Section 7).
> These functions can also be invoked in the COM 266 "TRANSMIT" (TRANSFER) form (see Section 6.4.2).

This mode is started automatically on the IP 266 run-up that follows a "Power ON". The IP 266 outputs an error message when the EEPROM contains no valid machine data.

The service life of an EEPROM chip is 10,000 write cycles.

Example:
The IP 266's RAM contains the following data block:
- One machine data record in DB1
- Several traversing programs in DB1 to DB4

When the mode is started for RAM→ EEPROM, both the machine data and the traversing programs are transferred. Any data in the EEPROM prior to the transfer is overwritten with the new data.

5.3.22 Unrestricted Speed Specification (Mode 31)

For some applications, the speed variation is not covered by the override factor. For this reason, the new mode 31 enables you to transfer the speed of your choice to the IP 266. This speed is then valid for modes 1, 2, 6 and 7. This newly defined speed is then used in place of the traversing speed entered in the machine data.

Note:

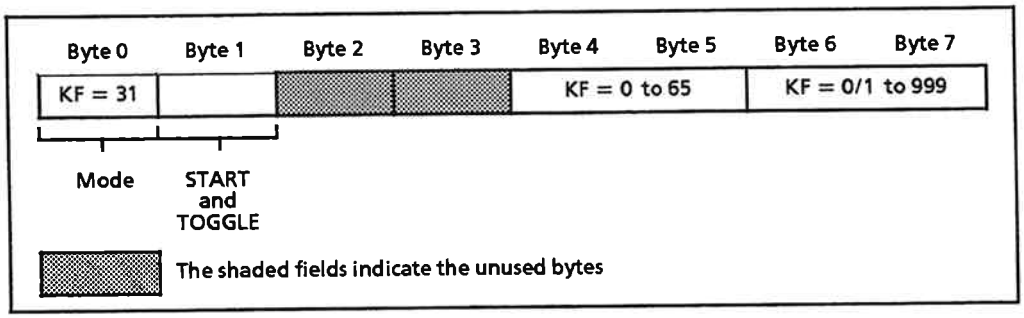
The speed specification does not overwrite the entry in the machine data.

It is still possible to vary this newly defined speed using the override factor.

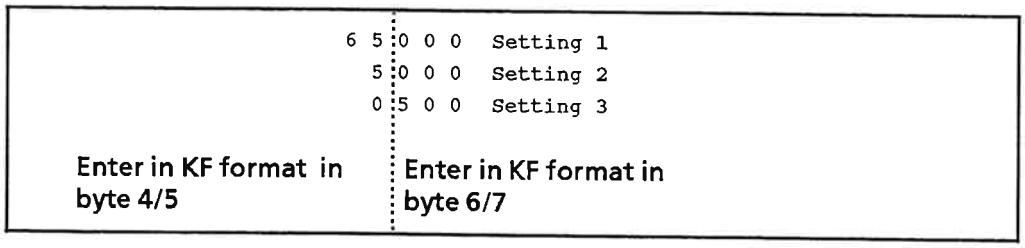
Value range
The speed specified must not exceed the value of the maximum speed in the machine data. If you enter a greater value, the IP 266 flags an error. The previously set mode remains in force.

Switching the speed to the parameterized machine data
If the value 0 is transferred as the new speed, this switches the IP 266 back to the parameterized machine data.

Overview of the operating mode
To select the functions, you must assign values in the output frame:



You must divide the value to be entered into two individual values and enter them in byte 4/5 and byte 6/7:



If the value 0 is set, the IP 266 switches back to normal mode.

Note:

Mode 31 is only signalled back to the CPU until mode 1, 2, 6 or 7 is invoked. It then still remains active but can no longer be signalled by reading out byte 0.
However, the following description "Enable control for mode 31" tells you how you can nevertheless establish whether mode 31 has been enabled.

A speed specified by mode 31 cannot be stored long term.
A "Power off" deletes a speed set by mode 31. This also has the effect of switching the IP 266 back to normal mode.
Mode 26 (Transferring from RAM to EEPROM) does **not** transfer this speed to the EEPROM of the IP 266.

Enable control for mode 31
When enabled, mode 31 remains active even after further invocation of mode 1, 2, 6 or 7. However, only the last invoked mode is flagged in the input frame; i.e. not mode 31.
You can read out a newly specified speed (BA 31) with mode 32. If you select this mode and read it out as the value "0", mode 31 is not enabled.

5.3.23 Reading out the Unrestricted Speed Specification (Mode 32)

Mode 32 extends the three information modes 71, 72 and 73. You can use mode 32 to read out the new traversing speed set with mode 31.

Note:

Only the speed entered by you is flagged, not the actual speed.

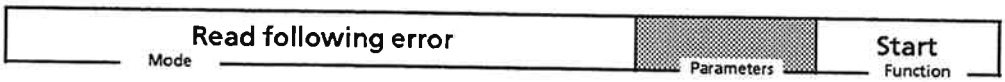
In order to invoke the mode, you need only assign KF = 32 to byte 0 in the output frame and set the START bit and invert the TOGGLE bit in byte 1 of the output frame.
No other bytes are significant for selecting the mode.

The value set by you is then signalled back to you by the IP 266 over the input frame in bytes 4 to 7.

Output Value After Invocation of Mode 32	
1 to 65000	0
Mode 31 is enabled. The new speed value is active for modes 1, 2, 6 and 7.	Mode 31 is disabled. Modes 1, 2, 6 and 7 take the speeds specified in the machine data

Information mode 32 remains active even after mode 31 has been disabled. You must therefore also change the information mode back again to another information mode (71, 72 or 73).

5.3.24 Disabling the Monitors (Mode 33)



Mode 33 allows you to disable the following monitors:
- Software encoder monitor (see Section 2.7.1) and
- Position control monitor (see Section 2.7.2).

If the torque from the motor is to be used not only for positioning but also for joining parts - e.g. pressing in screws - the mode must remain enabled until it is terminated by the program. This can result in pulses not being captured for a period in excess of 10 IP cycles (10*3.75 ms). It is necessary to disable the monitors in such cases in order to avoid the IP 266 aborting the job request with an error message.

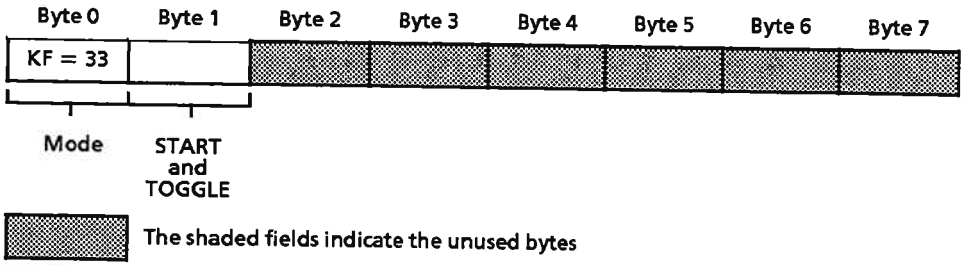
Caution

The following wirebreaks are **not** detected in the case of disabled monitors:
- Wirebreak of 24 V encoders
- Wirebreak in the setpoint line

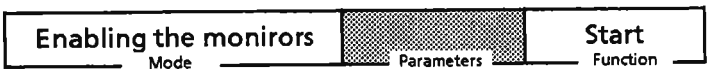
Note:

Hardware monitoring of the 5 V sensors is always active.

All monitors are active after a "Power off".
The output frame has the following structure for this mode:



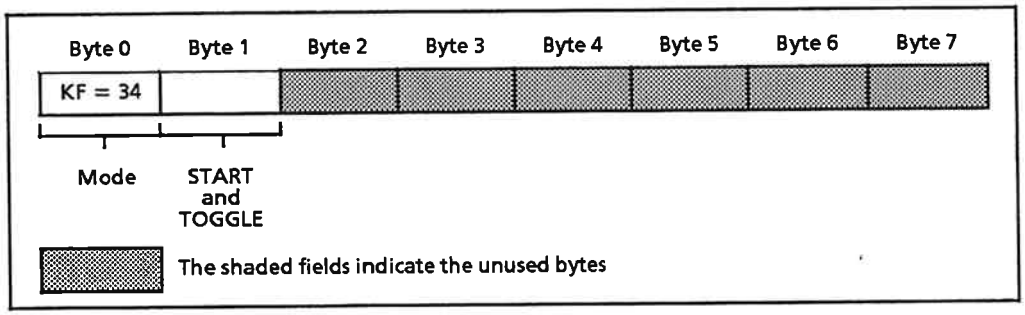
5.3.25 Enabling the Monitors (Mode 34)



The following monitors disabled by mode 33 can be re-enabled by mode 34:

- Software encoder monitor (see Section 2.7.1) and
- Position control monitor (see Section 2.7.2).

The output frame has the following structure for this mode:

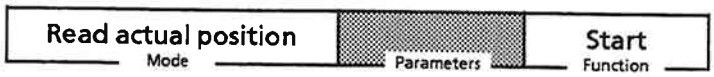


5.3.26 Information Modes (Mode 71, Mode 72, Mode 73)

Current information can be called up from the IP 266 independently of modes 1 to 19 and 26. The IP 266 provides the so-called Information (or Monitoring) modes for this purpose. These modes do not affect other modes, and can be invoked at any time without regard to the status of the axis.

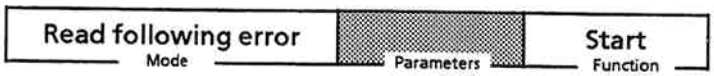
Once started, an Information mode is invoked cyclically, and remains in force until another Information mode is started.
In contrast to modes 1 to 26, modes 71 to 73 do not return information to the STEP 5 program.

Read actual position (mode 71)



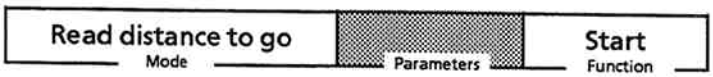
This mode is preset on IP 266 start-up, and displays the value which the IP 266 computed from the current encoder data and the machine data.

Read following error (mode 72)



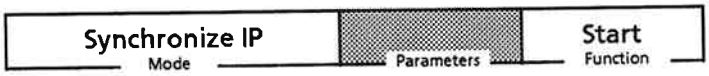
This mode allows you to read the following error so that you will have this information at your disposal should an abort due to a "Response from following error monitor" be imminent. This, in turn, allows you to react to an increase in the following error prior to the abort and take measures to rectify the problem.

Read distance to go (mode 73)



Select this mode when you want to initiate additional actions in your STEP 5 program prior to termination of an IP 266 job (e. g. 20 mm before the target position).

5.3.27 Synchronize IP (Mode 99)



This mode must be selected when the IP 266 is put into operation, as it synchronizes communication between the PLC and the IP 266.

This mode must be started after every PLC cold (power off/power on) or warm (STOP → RUN) restart and after every IP 266 reset. If this mode is not started, it will not be possible to invoke any other mode.

As in the case of the Information modes, this mode does not return information to the STEP 5 program.

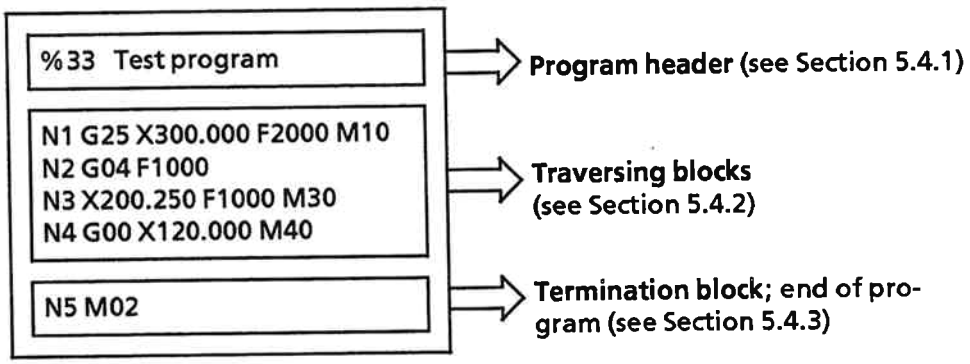
Note:

This mode is not needed to work with COM 266.

5.4 Elements of the Traversing Program

A traversing program is a cohesive sequence of traversing operations, dwells and corrections. It consists of individual blocks comprising at least one self-contained, purposeful job.
The traversing programs are stored in the IP 266's RAM, and can be executed as a whole with mode 8 or block by block with mode 9.

A traversing program is divided into three main parts:



A traversing program must comprise at least a program header and a termination block.

A traversing program may contain no more than 1023 ASCII characters. The number of traversing programs is limited to 250.

The IP 266 provides 7K bytes RAM for traversing programs.

5.4.1 Program Header

The program header comprises
- the program identifier
- the program number
- max. 58 characters of arbitrary text
- a <↵> character as header terminator

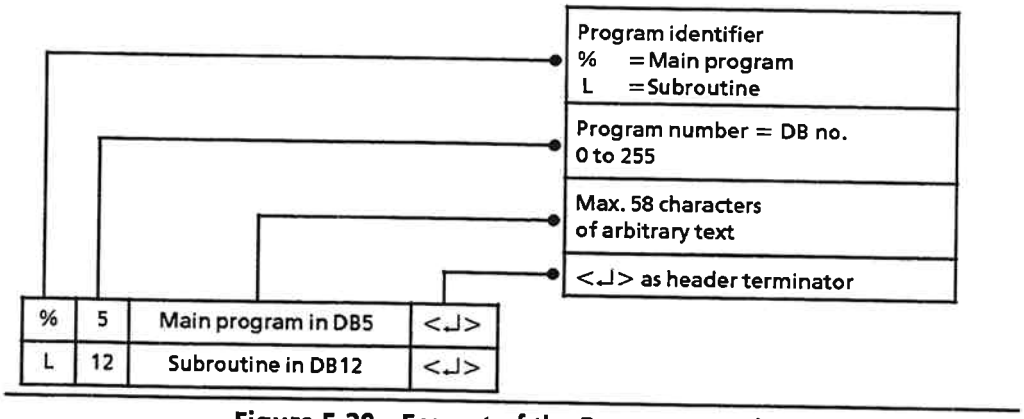


Figure 5-28. Format of the Program Header

The distinction between main program and subroutine is for documentational purposes only. The IP makes no distinction. Every program can be either a main program or a subroutine.

Note:

Recursive structures and reciprocal calls are not possible.

5.4.2 Traversing Blocks

Table 5-20 lists all functions permitted in a traversing program.

Table 5-20. Functions in a Traversing Block

Contents of a Traversing Block			
Function		Contents	Type of information
Block no.	N	Block number Subroutine Calls	Organization
Function 1	L		
Function 2	G	E. g. type of position specification (absolute/relative)	Preparatory
Function 3	X	Positioning information	Geometry
Function 4	F	E. g. machining speed, dwell time, loop passes	Technology
Function 5	M	Auxiliary functions (output to the PLC interface for control of machine functions)	

A block may contain one or more of the functions listed in the table. Each block must begin with a block number. If several functions are to be programmed in one block, they must be programmed in the order shown in the table. Each function may appear only once in a given block and must be followed by at least one <space>. Every block must be terminated with <↵>.

The N function (block number)
The first function in a block, the N function, specifies the block number. This block is mandatory, and consists of the letter "N", followed by a number comprising up to three digits in the range 0 to 999.

Block numbers may appear in any order, and may be used more than once within a traversing program.

The blocks are always processed in the order in which they are written in the traversing program.

In the following example, the processing order does not change. The order in which blocks are processed is determined only by the order of those blocks in the program.

Example:

%9 Sample program 1	%8 Sample program 2
N10 G74 M10	**N30** G74 M10
N20 G24 F5	**N10** G24 F5
N30 L36	**N20** L36
N40 X50 F2000	**N60** X50 F2000
N50 G20	**N50** G20
N60 M02	**N40** M02

The two sample programs are identical.

The L function
Within a block, another program can be called as subroutine. The subroutine call must immediately follow the N function, and comprises the letter "L", followed by the program number of the program to be called.

No further functions may follow the L function. The block may only be terminated with <↵>.

Example: N10 L123 <↵>
⋮

Subroutines may be nested, but the nesting depth of loops and subroutines together may not exceed five.

Note:

Recursive structures and reciprocal calls are not possible.

The G function

The first function to follow an N function may also be a G function. A G function is identified by the letter "G", followed by a two-digit number. A number of G functions are latching functions, i. e. they remain in force when the traversing program is exited.

Table 5-21. Permissible G Functions

G Function	Latching	Function Description
00		Rapid traverse
04		Dwell
10		Flying change
20		End of loop
24		Start of loop
25*	•	Approach targets over the shortest path
26	•	Approach targets in a clockwise direction (rotary axis only)
27	•	Approach targets in a counter-clockwise direction (rotary axis only)
40		Cancel tool offset
43		Enable positive tool offset
44		Enable negative tool offset
53		Cancel offsets
54		Enable offset 1
55		Enable offset 2
56		Enable offset 3
57		Enable offset 4
70	•	Size specifications in 0.1 inches
71	•	Size specifications in mm
74		Approach to reference point
90*	•	Absolute size specifications
91	•	Incremental size specifications

* These functions are preset on IP 266 start-up

- G00: Rapid traverse
  A defined target is approached at maximum speed. The target must be specified as an X function immediately behind the G function.

  A block containing the G00 function must have the following format:

  N10 G00 X1000

  The drive approaches target position 1000 at maximum speed.

  An additional speed specification after the X function is not permitted.

  The maximum speed is taken from the machine data.

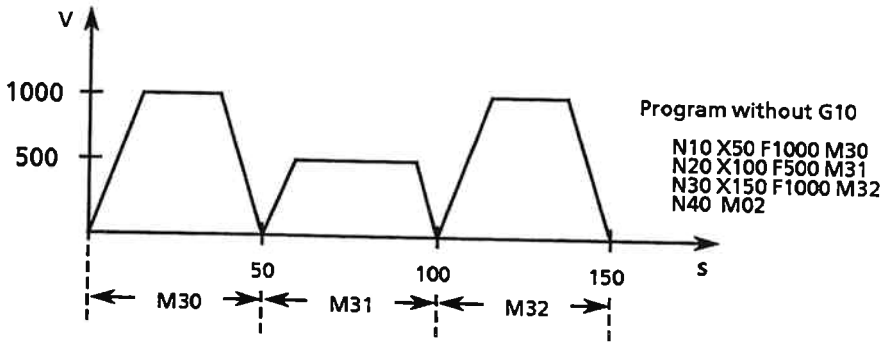
- G04: Dwell
  A block containing G04 effects a dwell. The duration of the dwell can be specified in increments of 100 ms with the F function.
  Example: N10 G04 F10
  The IP executes a dwell of 10 x 100 ms.

- G10: Flying change
  The block that follows the one containing the G10 function is executed without stopping the axis.

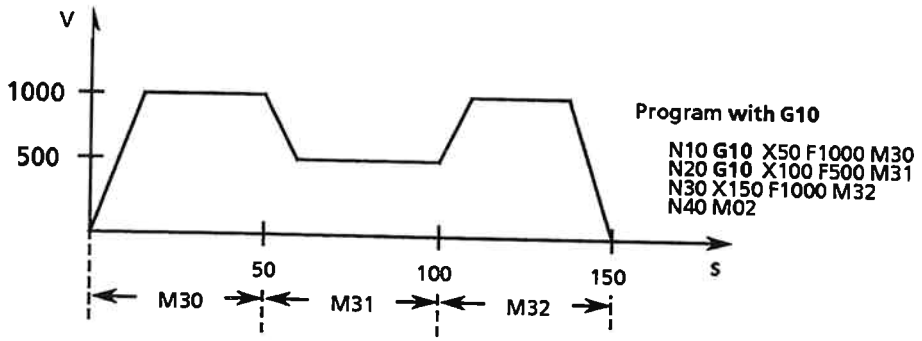
  This makes it possible to
  - change the speed during a positioning movement
  - modify M functions during a continuous positioning

> **Note:**
>
> By retracting the "External Start Enable" signal, you can also interrupt a block that was linked to the preceding block via G10.

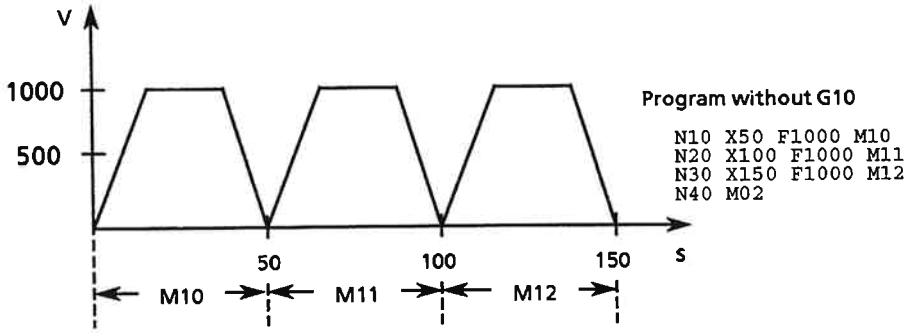
Example 1: Changing the speed during a positioning movement



The G10 function makes of the interrupted movement a positioning operation with smooth speed transitions.

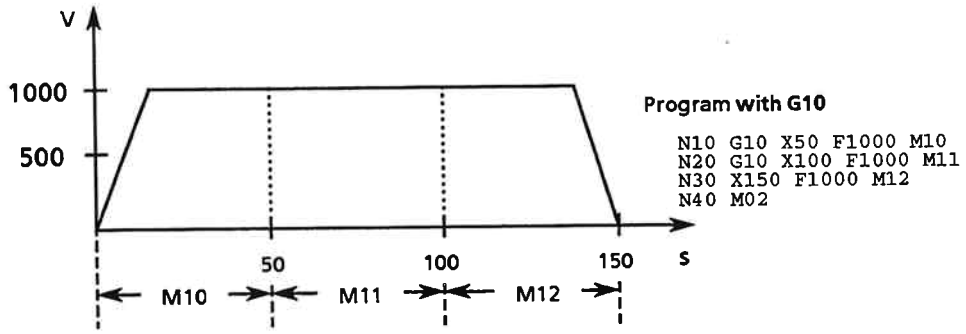


Example 2: Alternating M functions



Without the M function output, this movement could also be programmed in a block:
N10 X150 F1000

A smooth movement of the type programmed in this block can be attained with the G10 function.



The "Position reached" signal is not output following a block containing a G10 function.

In mode 9 (Automatic Single Block), blocks linked with G10 are treated as one block.
When G10 and M00 (programmed stop) are programmed in the same block, M00 has priority.
To continue the program, you must press the EXEC key.

The G10 function (flying change) is not permitted when the block to follow in a flying change

- acts in the opposite direction
- contains a dwell
- contains only an M02
- is too short to reach the required final speed
- contains a change, a tool offset or a zero ofset
- contains a traversing path which is shorter than the preceding block's deceleration distance
- could not be completely interpreted before the block containing the G10 finished executing

The traversing program interpreter aborts the program immediately when it detects one of the above errors. Because the interpreter is always three blocks ahead of the block currently executing, however, the program is aborted in the current block rather than in the block that actually caused the error.

Example:
A traversing program containing eight positioning operations is to be processed. The first seven blocks contain a G10 function, i. e. all blocks are to be executed without stopping in "flying change" mode.

The eighth block, however, was programmed so that a change of direction would ensue. The interpreter detects this error and aborts the fifth block, the block currently executing.

Program:

```
N10 G10 X50 F100
N20 G10 X80 F200
N30 G10 X130 F300
N40 G10 X155 F400
N50 G10 X200 F500    <--- Traversing program aborted
N60 G10 X240 F600
N70 G10 X280 F700
N80 X0 F800          <--- Block with error
N90 M02
```

- **G20: End of loop**
  G24: Start of loop
  Loops may be nested. Subroutines which themselves contain loops may also be called in a loop. The nesting depth for loops and subroutine calls together may not exceed five. A continuous loop may be programmed only once, and only at the highest level. A program invoked via an L function may not contain a continuous loop.

  G20: End of loop
  G20 identifies the end of a program loop. A block containing G20 may contain no other functions.

  G24: Start of loop
  The G24 function identifies the start of a program loop.
  The number of loop passes must be specified via the F function.

Example 1:	N20	G24	F5	A loop with five passes begins on this line
		⋮		
	N120	G20		The loop ends on this line
Example 2:	N20	G24	F0	When you specify a 0 as the parameter for the number of loop passes, you define the loop as continuous loop.
		⋮		
	N130	G20		End of the continuous loop.

- **G25: Approach target over the shortest path**
  G26: Approach target in a clockwise direction
  G27: Approach target in a counter-clockwise direction
  These functions can be executed for a rotary axis only, and are ignored for a linear axis.

  G25: Approach target over the shortest path
  When the program is invoked, it defaults to G25. The IP computes the direction of travel. If the distance is the same in both directions, the target is approached from the preferred direction (clockwise).

  The IP does not take backlash compensation into account when computing the direction, thus making it possible that the longer path will be taken in a small number of special situations. Figure 5-29 illustrates such a situation.

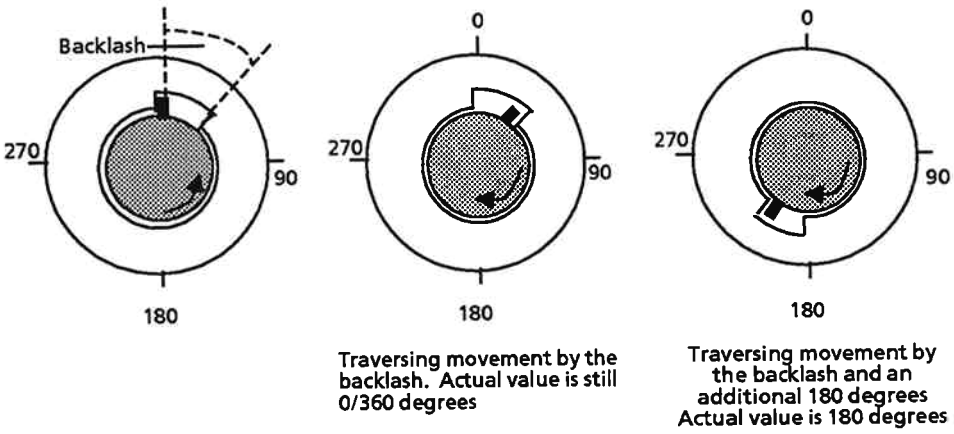


Figure 5-29. Traversing of a Rotary Axis with Backlash

Prerequisites:
- The backlash compensation value was entered in the machine data
- G25 was programmed and the distance is the same in both directions
- The direction of travel in the last operation was counter-clockwise

Result: The IP 266 chooses the preferred direction. Due to the programmed backlash, the movement takes longer than it would in the opposite direction. The distance for the motor-driven axis is longer by the backlash compensation value.

The function selects the direction of travel only when absolute target positions have been defined.

G26: Approach target in a clockwise direction
All absolute target positions are approached in a clockwise direction.

G27: Approach target in a counter-clockwise direction
All absolute target positions are approached in a counter-clockwise direction.

G26 and G27 are effective only in conjunction with "Absolute size specifications" (G90).

- **G40: Disable tool offset**
  G43: Enable positive tool offset
  G44: Enable negative tool offset

  A tool offset can be regarded as a coordinate shift, and is required to compensate for changes in the tool length caused by tool wear. An existing traversing program need not be reprogrammed to include a tool offset, but is adapted via a compensating factor.

  Periodic tool wear (e. g. drill wear) can be measured and corrected using the G functions. The following table shows the effect of a tool offset.

Table 5-22. Tool Offset

Positioning direction	Suitable tool Offset ± 0 mm	Tool too short Offset -5 mm	Tool too long Offset +5 mm	Note
Set-point 85 95 100 105	15 mm	10 mm, -5 mm	15 mm, +5 mm	Prior to tool offset
Set-point 80 85 90 100				Following tool offset and subsequent positioning operation

The offset value for functions G43 and G44 is in the machine data on the IP 266.

In contrast to mode 15, offsets via G functions are additive offsets which change the total tool offset value by the value of the programmed offset (see Section 5.3.15).

The following TO limiting values apply for the resulting tool length change:

Values	Linear axis	Rotary axis
Maximum offset value	±32 767.999 mm	End of range - start of range
Software end limit switch + offset value	< 32 767.999 mm	———
Software start limit switch + offset value	< 32 767.999 mm	———

If a traversing program containing a G function for a tool offset is terminated without the G40 function, the current additive offset is retained.

The additive value can then be reset to zero only together with the external (offset) value in mode 16 (see Section 5.3.16).

Entry of a new external offset in mode 15 also resets the additive value to zero.

- G40: Disable tool offset
  The G40 function disables all positive and negative tool offsets in a traversing program.

- G43: Enable positive tool offset
  The G43 function enables a positive offset of the length specified in the machine data.

- G44: Enable negative tool offset
  The G44 function enables a negative offset of the length specified in the machine data.

You are now acquainted with the various options for tool offsets, i. e. the tool offset initiated with mode 15, which can be used as absolute tool offset, and the tool offset initiated via the G functions, which is an additive tool offset.

The diagram below shows the interplay between modes 15 and 16 and G functions G40, G43 and G44.

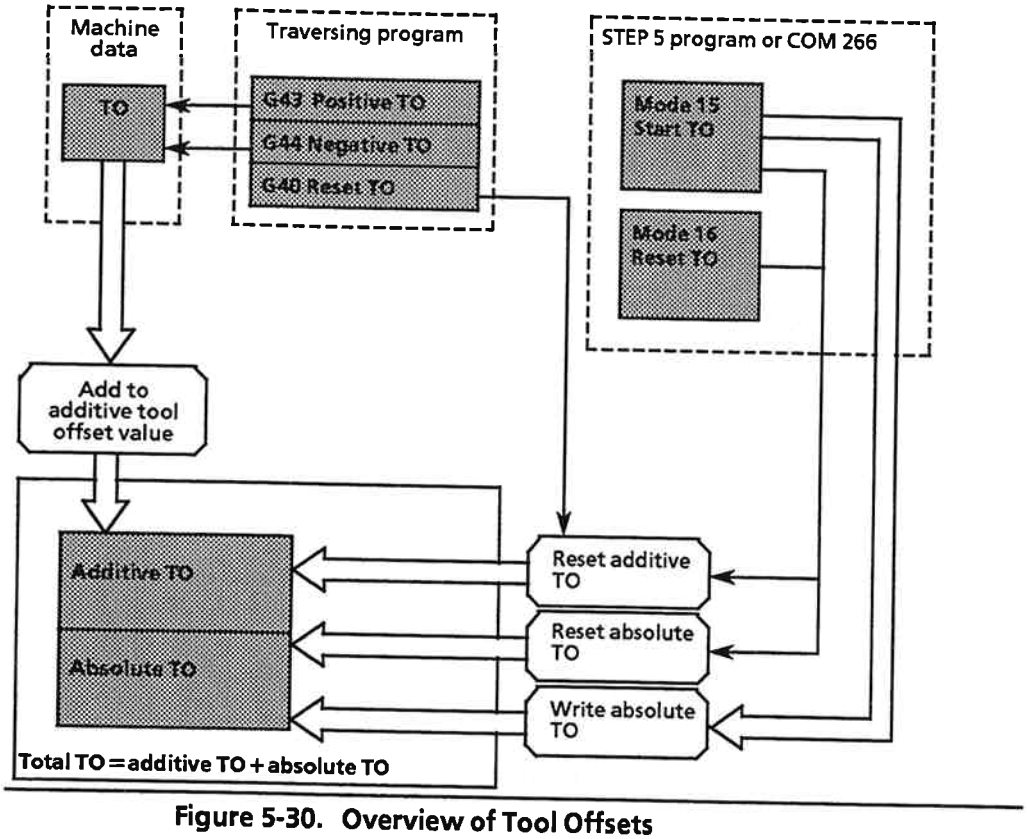


Figure 5-30. Overview of Tool Offsets

- **G53: Cancel zero offsets**
  G54-G57: Enable offset 1-4
  These functions effect a relative shift in the axis's coordinate system. Such a shift may be required when it is necessary to perform identical steps with the same incremental dimensions at different positions (see Example).

  Example: Using a zero offset
  Only one zero offset may be invoked at any given time. A zero offset enabled via G54 remains in force only until another G function (G54 - G57) is invoked.

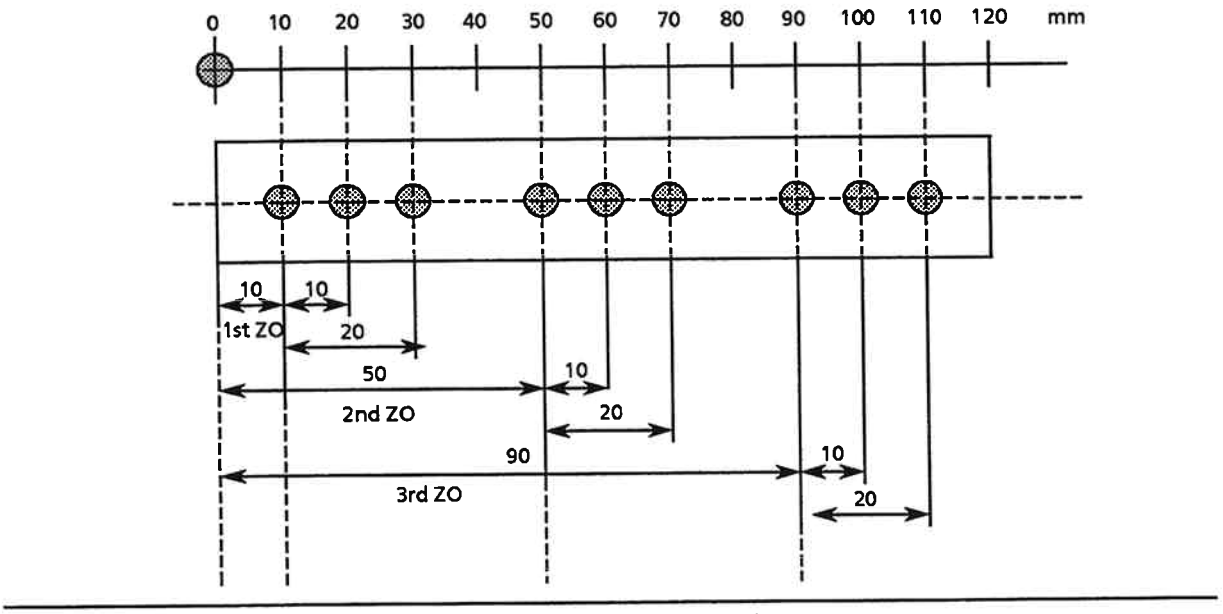


Figure 5-31. Using Zero Offsets

The workpiece is to be drilled at the points indicated.
The three drill holes in each group are the same distance apart. The machining sequence for the groups can be programmed in a subroutine.

Zero offsets and positioning operations are used to set the start position for the subsequent subroutine-controlled positioning of the drill.
Rough structure of the program:

1. ZO forward + 10 mm (e. g. ZO 1)
2. Call subroutine for the three drill holes at the positions 10 mm, 20 mm and 30 mm
3. ZO forward + 50 mm to absolute position 50 mm (e. g. ZO 2) and positioning to the start position
4. Call subroutine for the three drill holes at the positions + 50 mm, 60 mm and 70 mm
5. ZO forward to absolute position + 90 mm (e. g. ZO 3) and positioning to the start position
6. Call subroutine for the three drill holes at the positions 90 mm, 100 mm and 110 mm

Four offsets can be entered in the machine data. The sign indicates the direction of the offset.
A G function is assigned to each offset.

- Zero offset 1 → G54 (10 mm)
- Zero offset 2 → G55 (50 mm)
- Zero offset 3 → G56 (90 mm)
- Zero offset 4 → G57 (150 mm)

A G-function zero offset is added to both the absolute and relative zero offsets set via modes 12 and 13. The offset value modifies all coordinate values for
- software limit switches
- reference point
- coordinate zero point

Enabled zero offsets are automatically reset when the traversing program terminates.
Zero offsets set in a subroutine are not reset until the main program is exited.
The G53 function resets the zero offsets set in the traversing program and the associated subroutines.

Note:

When you abort a traversing program, the set zero offsets are retained, and can be reset only via mode 14.

- G53: Cancel offsets
  This function disables the zero offsets enabled in the traversing program.

Table 5-23. Effect of Function G53

These ZOs are disabled	These ZOs are not disabled
ZOs enabled in the traversing program ZOs enabled in the traversing program's subroutines	Absolute ZOs set via mode 12 Relative ZOs set via mode 13

- G54 - G57: Enable offset 1-4
  A block containing one of these G functions enables a zero offset.

Figure 5-32 shows how zero offsets interact and how they can be cancelled.

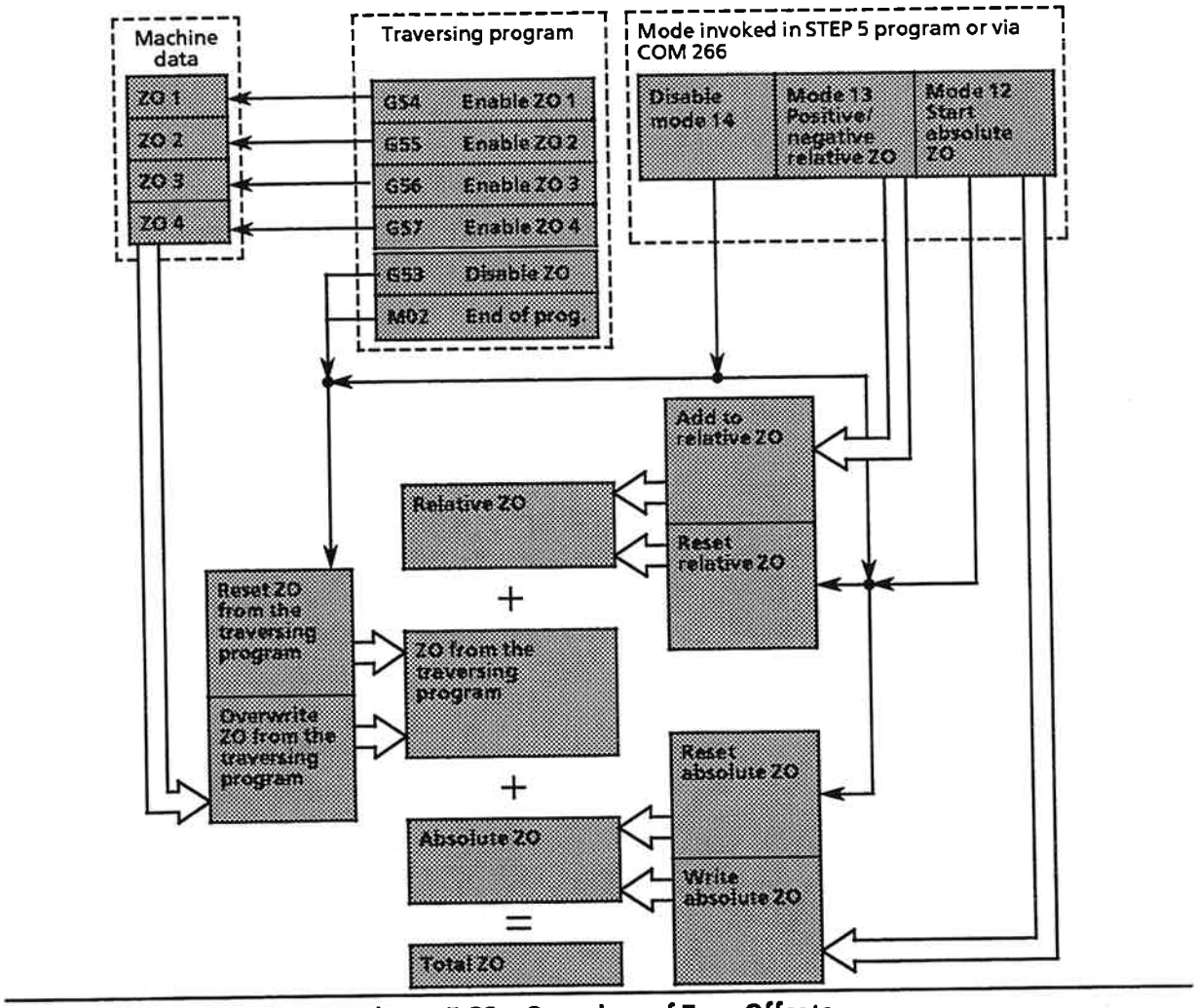


Figure 5-32. Overview of Zero Offsets

- **G70: Dimensions in 0.1 inch**
  G71: Dimensions in mm
  The IP 266 positioning module always interprets traversing programs in the dimension specified in the machine data.

Table 5-24. Preselecting Dimensions

Dimensions in the unit	Invoke via function
[0.1 inch] [mm] [degrees]	G70 G71 G70 and G71 ineffective

Functions G70 and G71 can be used to change the dependence of dimensions on the specification made in the machine data.

Note:

G functions cannot be used to implement this options for a rotary axis that was initialized in [deg] in the machine data.

- G70: Dimensions in 0.1 inch
  When the G70 function is invoked, all subsequent distances are interpreted in units of 0.1 inches and all subsequent speeds in 0.1 inches/min.

- G71: Dimensions in mm
  When G71 is invoked, all subsequent distances are interpreted in mm and all subsequent speeds in mm/min.

- **G74: Approach to reference point**
  This function can be used to approach an existing physical reference point. The position specified by the value of the reference coordinate is not approached; this position may differ from that of the physical reference point due to compensations or offsets.

  The incremental speed specified in the machine data is used as approach speed.

Note:

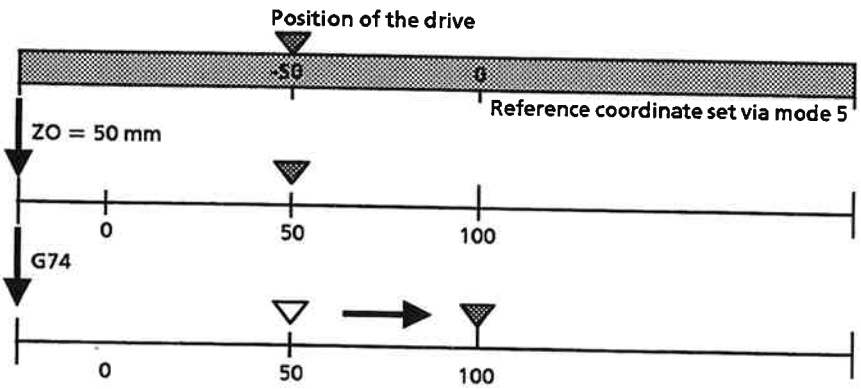
The G74 function does not execute a reference point approach on the same basis as mode 5.

The zero offsets and tool offsets currently in force are taken into account in the actual-value display.

Example:
Following an approach to reference point and subsequent positioning, the drive is at the position - 50.

Following a zero offset, the actual position is 50 mm and the reference point position is 100 mm.

Function G74 moves the drive to the position 100 mm, which is the physical zero point (not to coordinate 0, which is the reference coordinate specified in the machine data).



- **G90: Absolute position specifications**
  G91: Relative position specifications
  These two G functions control the interpretation of all target specifications (X functions).

  G90: Position specifications are interpreted as absolute values
  G91: Position specifications are interpreted as relative values

  These two G functions control the interpretation of all target specifications (X functions).

The X function
In this function, the character "X" is followed by a target coordinate for the positioning operation.

The target coordinate may be specified as either an absolute or relative value (can be selected via G90/G91).

The numerical value may comprise up to five integer and three decimal places and a sign.
Max. +32767.999
Min. -32767.999

The decimal point may be omitted if the value has no decimal places, and is then assumed to be located at the last position in the target specification.

If BCD format was specified in the machine data, the target coordinate must be in the range from + 9999.999 to - 9999.999.

The F function
How an F function is interpreted depends on the function which precedes it.

Table 5-25. Using the F Function in Traversing Blocks

Preceding function in the block	The F function is interpreted as	Value range	Unit
G04	Dwell	1 to 65000	Multiple of 100 ms
X function, except for X function following G00	Speed	10 to 65000	mm/min 0.1 inches/min degrees/min
G24	Number of loop passes	0 to 65000 0=Continuous loop	

The "F" must be followed by an unsigned integer comprising no more than five digits.

The M function
M functions are auxiliary functions used to control external events. An M function consists of the letter "M", followed by a number of no more than two digits. The binary value of that number is forwarded to the programmable controller, where it can be evaluated to control other modules or as status info on a positioning operation.

With the exception of the function M00, M functions following switching functions, compensation values or offsets have no effect, and are ignored. The M function that was active before the block was invoked remains in force.

The IP 266 interprets the M00, M02 and M99 functions directly.

- **M00: Programmed stop**
  M00 interrupts a program for mode 8 or 9. The program can be resumed by pressing the EXEC key.

  In a block containing both M00 and G10, M00 has priority.

  An "External stop" is not executed while an M function is in progress.

- **M02: End of program**
  This function must be programmed in the last block of a main program or subroutine.

- **M99: External switching function**
  This switching function is applied directly to an IP 266 digital output. This output is connected with pin 10 on the terminal block.

  All other values (i. e. M01 and M03 to M98) are available to the user.
  An M function is output when execution of a block begins, and remains in force until the next M function is output.

  If a traversing program begins with blocks in which no M functions have been programmed, M255 is output to the PLC. One byte is available for the display. The value "FF" is displayed if the format is KH, the value "-1" if the format is KF.

5.4.3 Last Block

The last function programmed in the last block of a traversing program must be an M function with the parameter 02. The format of the last block is the same as that of all other blocks.

In its shortest form, the last block must contain
Nnn M02 <↵>

5.4.4 Syntax Diagram of a Block

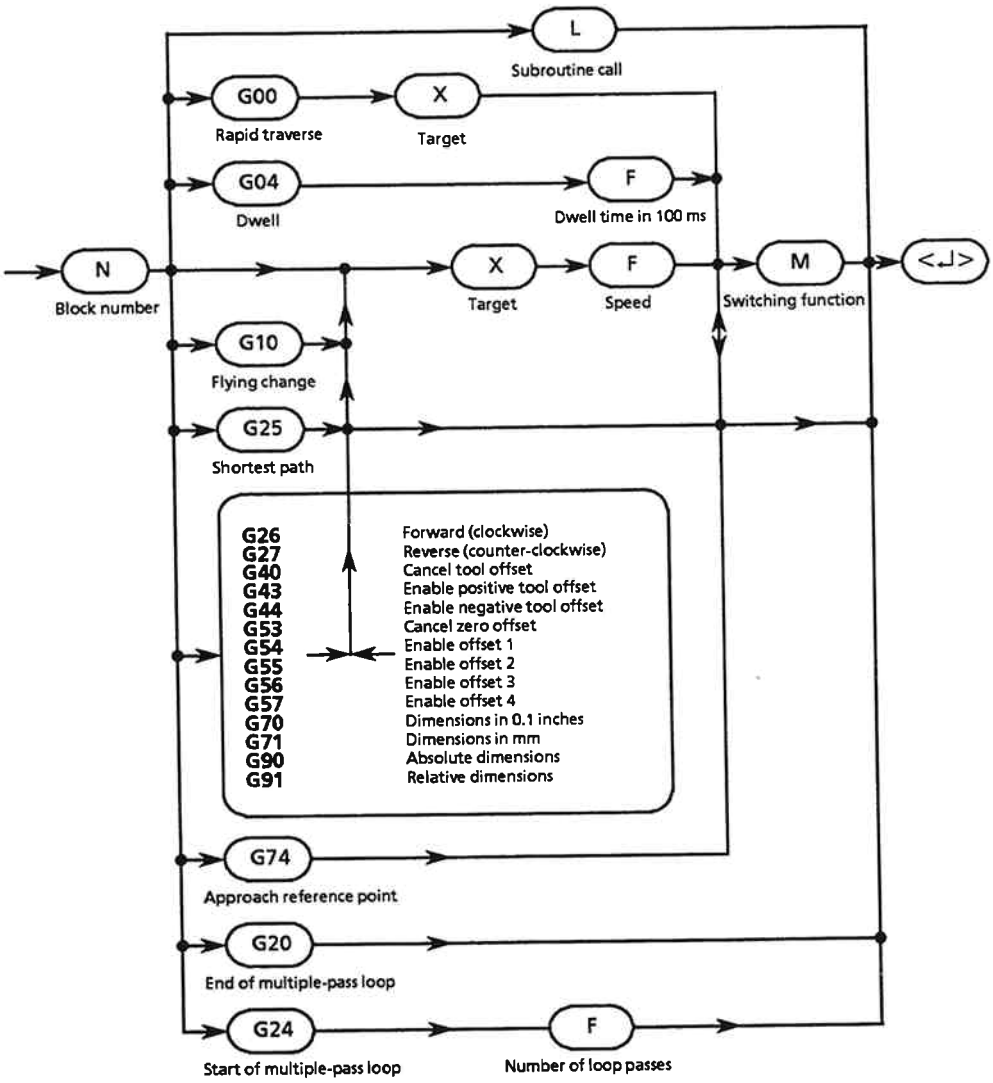


Figure 5-33. Syntax Diagram of a Block

The Figure above shows all permissible combinations of functions within a block.

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6 Fundamentals of COM 266

The COM 266 software provides user-friendly support for programming the IP 266 and putting it into operation. All functions can be executed by making the appropriate entries in the interactive screen forms. The relevant program sections are invoked via function keys.

In order to acquaint you with the COM 266 software and how to use it, Section 6.1 provides information on

- making a working copy of the COM 266 floppy
- configuring a system
- starting COM 266 and making all initial preparations for its use

You will then find an overview showing you the hierarchical structure of the COM 266 software. Section 6.2 provides general information on the COM 266 screen forms which precede the "FUNCTION SELECT" form. The subsequent sections describe all available COM functions.

6.1 Preparations for Using COM 266

Before putting COM 266 into operation, you should first copy all the files you need to a floppy.

Standard package
COM 266 is delivered on a floppy disk in the format required by the S5-DOS operating system. Make sure that S5-DOS has been installed on your programmer.

6.1.1 Copying the COM 266 Floppy

Before you start, make a copy of the original COM 266 floppy and store it in a safe place.

- ▸ Start the PCP/M86 operating system
- ▸ Copy the original COM 266 floppy
  PCP/M86 provides a utility for formatting and copying floppy disks.

To call this utility,

- enter DSKMAINT <↵> if you are using an older version of PCP/M-
- or DISK <↵> if you are using the newest version

Please refer to your programmer manual for a detailed description of this utility.

6.1.2 System Configuration

- First of all, you should learn how to install COM 266 on your hard disk.
  - ▸ Load the PCP/M86 operating system
  - ▸ Insert the COM 266 floppy into drive A

  You must now copy the contents of the floppy to USER extent 0 on the hard disk.
  - ▸ To do so, enter the following line:
    PIP B:=A: S5 PDC 13X.CMD <↵>
  - ⇒ This command copies the COM 266 program to USER extent 0 on your hard disk.

  In order to make it possible to invoke COM 266 from any USER
  - ▸ Set these file attributes with:
    SET B: S5 PDC 13X.CMD[RO SYS] <↵>
  - ⇒ The program is now installed.

  When you start S5-DOS, COM 266 will now appear in the "PACKAGE SELECT" menu.

- Preparations for using a programmer that is not equipped with a hard disk unit:
  First, you must generate an S5-DOS floppy. To do so, copy the following files to a new or blank floppy that has been formatted for PCP/M86:
  S5WX000H.CMD
  S5WX100X.CMD
  S5WX200X.CMD
  S5WX201X.CMD
  S5WX202X.CMD
  S5.CMD
  S5KXS02X.CMD
  S5KDS01X.DAT
  S5KDS02X.DAT

6.1.3 Starting COM 266

You can start the COM 266 program from either the hard disk or the floppy.

- Preparations for a programmer equipped with two floppy disk drives:
- ▸ Activate drive A by entering A: on the command line and pressing <↵>.
- ▸ Insert the S5-DOS floppy into drive A and the COM 266 floppy into drive B.

- Preparations for a programmer equipped with a hard disk drive:
- ▸ Activate drive B

- Starting S5-DOS:
- ▸ Enter the following line:
  S5
  and press <↵>.

⇒ The KOMI screen form appears briefly during loading

Simatic S5	S5-KOMI	
Serial-No.:	xxxx-yyyy-zzzzzz	All rights reserved
Copyright (C) 1989		SIEMENS AG

Figure 6-1. KOMI Screen Form

This screen form is then replaced by the "PROGRAM SELECT" menu.

- ▸ Using the cursor control keys, select the COM 266 program in the "PROGRAM SELECT" menu.
- ▸ Start program loading by pressing function key <F1>.

⇒ "CONFIGURATION", which is the first of the COM 266 screen forms, is displayed on your screen.

The "CONFIGURATION" form

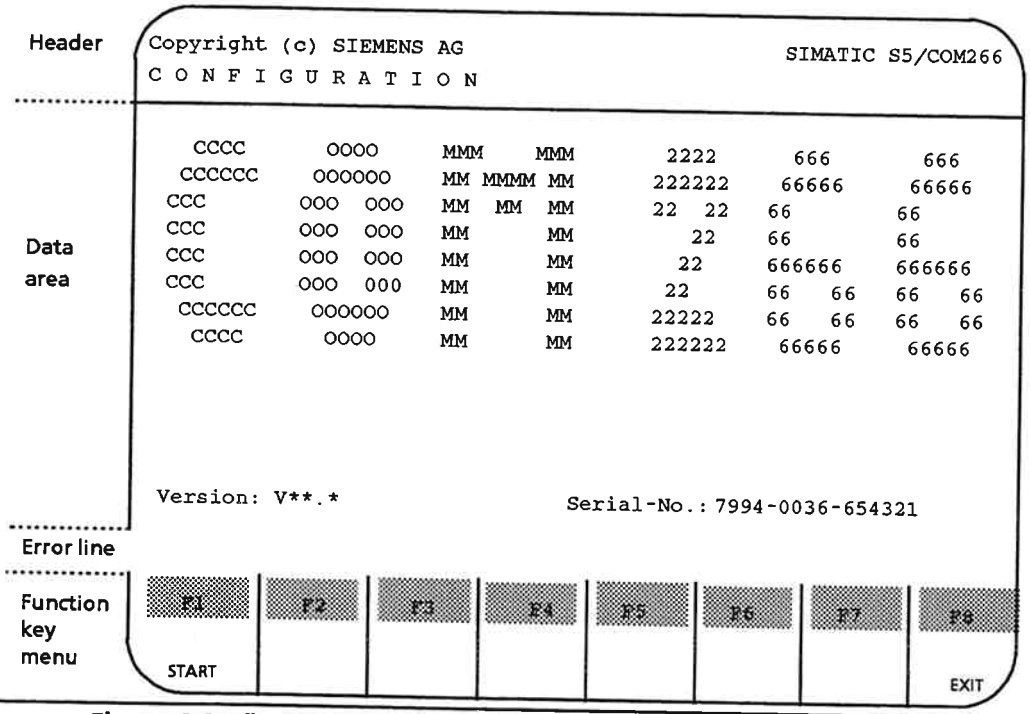


Figure 6-2. "CONFIGURATION" Form; COM 266 Screen Layout

Every COM 266 screen form is divided into the four sections shown above.

- Header
- Data area
- Error line
- Function key menu

Header:
The two-line header for each screen form comprises six subfields.

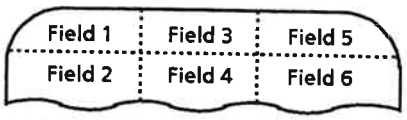


Figure 6-3. Format of the Header Lines

Each of these fields contains information specific to the screen form in which they appear. This information is listed in Table 6-1.

Table 6-1. Contents of the Fields in the Header Lines

Field	Contents
1	In screen forms that have subordinate screen forms or functions, this field contains the name of the basic, i. e. supraordinate, screen form. In the basic screen form itself, this field is blank [1] (see the Example for fields 1 and 2).
2	Field 2 always shows the name of the on-screen form.
3	Field 3 is blank in all screen forms.
4	In some screen forms, this field contains a device identifier. This identifier depends on the the screen form, and is explained in those screen forms in which it appears.
5	This field always contains the text "SIMATIC S5/COM266".
6	This field is screen form-dependent. In some screen forms, it contains the text "Block:DB...". The field content is explained in those screen forms in which the field is displayed.

1 Exception: In the "CONFIGURATION" form, this field contains the copyright entry.

Example for fields 1 and 2:
In the "INPUT MACHINEDATA" form, "INPUT" is the name of the basic screen form and is displayed in field 1 of the header.
MACHINEDATA" identifies the current screen form, and is displayed in spaced type in field 2.

Data area:
The data area of a screen form provides information on

- the machine data
- the defaults
- the configuration parameters
- Traversing (machining) programs

The data area is subdivided into the following fields:

- Fields with fixed texts
  A fixed text describes the relevant item of data.
  Input fields are displayed in reverse video. These fields are shown in the manual on a gray background. You may change the contents of these fields.
- Output fields
  An output field provides information on data already entered. In the screen forms, an output field is always preceded by a colon. Data in an output field cannot be changed.

Error line:
If errors occur during program execution, an appropriate error message is displayed on this line. Auxiliary messages and control information are also displayed on the error line. Each error message comprises an error code followed by an error text. The same error code is entered in the error byte in the STEP 5 message block.

Function key menu:
- The function key menu shows the functions which can be invoked in a screen form. A function is selected by pressing the function key allocated to it.
- You can exit each screen form by pressing <F8>. In many cases, you must confirm the exit request by pressing <F1>.

> **Note:**
>
> In the screen forms which follow, you will see data in various input and output fields. This data is only sample data to demonstrate possible field entries.

And what now?
▸ Start the COM 266 program by pressing <F1>.

⇒ The "PRESETS" form now appears on your screen. The entries in this screen form define the working environment for both the IP 266 and COM 266.

"PRESETS" form

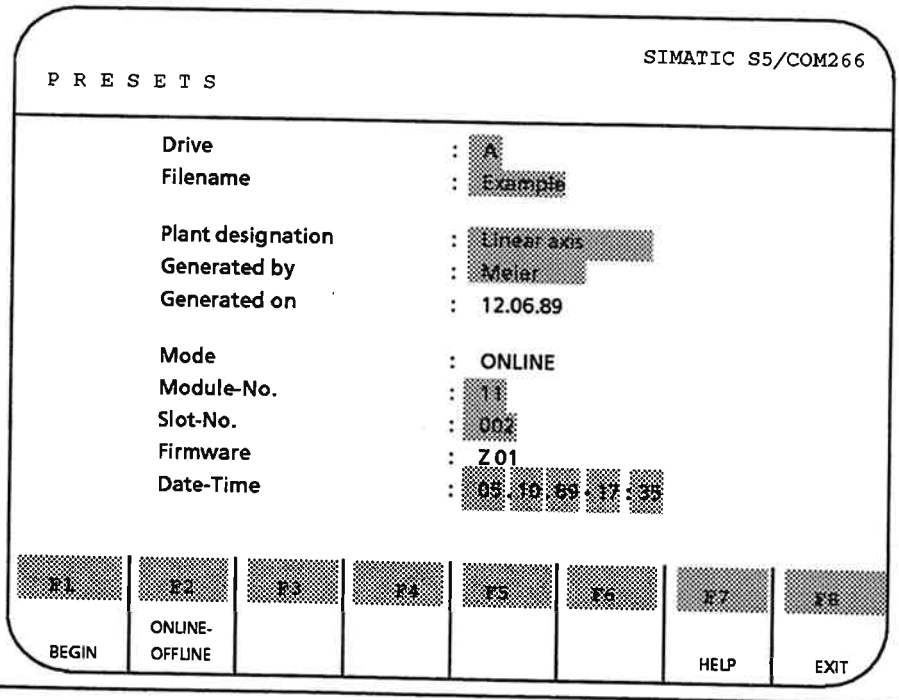


Figure 6-4. Initializing the IP

Header:
The header contains the following information:

- The name of the screen form in field 2 : PRESETS
- The name of the software package in field 5 : SIMATIC S5/COM 266

Data area:

Field name	Type	Description
Drive:		Specifies the current drive.
Filename:	I	The filename specifies the file in which your data blocks are to be stored. You can thus assign different files to different projects or plants. Press <F7> to display files with file extension 266.
Plant designation:	I	An entry in this field is mandatory. If the field is blank, the error message "Inadmissible input" is displayed. Enter a short characterizational text in this field.
Generated by:	I	An entry in this field is mandatory. Enter your name. If you entered the name of an existing file under "Filename", a name will automatically appear in this field.
Generated on:	O	If you entered the name of an existing file, its creation date is displayed in this field. If you are creating a new file, the current date and time is displayed.
Mode:	O	Operational status "ONLINE" or "OFFLINE". You can change back and forth between the two with <F2>, but "ONLINE" will appear only when the programmer is interfaced to the IP.
Module-No*:	I	You may enter a number between 0 and 99 to identify a specific positioning module in a programmable controller. If machine data has already been stored on the module, you must enter the same module number in this field as you entered in the machine data. (You cannot assign different module numbers to the same module).
Slot-No*:	I	The slot number may theoretically be in the range from 0 to 255, but should be between 0 and 7. This number is for the purpose of documentation only.
Firmware*:	O	The firmware version is displayed in this output field.
Date-Time:	I	The programmer's hardware clock data is displayed in this field. When you change these values, you reset the PG clock. When the programmer is switched off, this setting is lost again.

"Type" column: I = input field, O = output field

* The contents of these fields can be changed only when the operational status is ONLINE.

Function key menu:

<F1> This key
- takes you to the next screen form and
- forwards the initialization data to the module when correct entries have been made in all input fields.

<F2> This key is used to switch back and forth between "ONLINE" and "OFFLINE" in the "Mode" field.

The following values are read out from the module and displayed in the screen form in "ONLINE" mode:
- Module number
- Slot number
- Firmware version

The first time COM 266 is started, the module number and slot number fields are "0". These fields are not displayed in "OFFLINE" mode.

<F7> This key is used to display a list of available
- drives or
- file names.

<F8> Press this key to return to the "CONFIGURATION" menu.

And what now?

- Fill in all input fields in the "PRESETS" form.
- Press <F1> to display the "FUNCTION SELECT" form.

6.2 The "FUNCTION SELECT" Menu

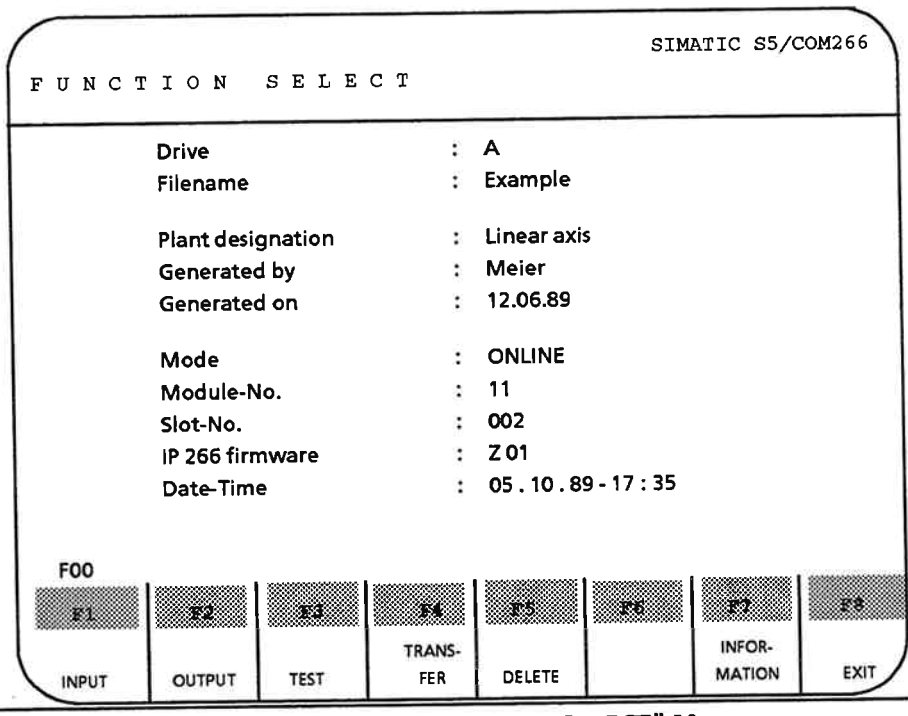


Figure 6-5. "FUNCTION SELECT" Menu

The "FUNCTION SELECT" menu relists all data from the "PRESETS" form. All fields in this screen form are output fields; none of the values can be changed.

You can invoke a series of functions in this screen form. When you abort a function with <F8> (EXIT), COM returns you to the "FUNCTION SELECT" menu.

Function key menu:

<F1> Press this key to branch to the screen forms for entering
- machine data and
- traversing (machining) programs.

<F2> Press this key to display
- machine data and
- traversing (machining) programs.

<F3> This key is used to invoke the branch of the program used to test modes 1 to 19, and may be pressed in "ONLINE" mode only.

<F4> Press this key to invoke the "Transfer" function.

This function is used to transfer
- machine data or
- traversing (machining) programs from memory to various storage media.

<F5> Press this key to invoke the "Delete" function.

This function is used to delete
- machine data and
- traversing (machining) programs from various storage media.

<F7> If you want to find out which machine data and traversing (machining) programs are on which storage media, press this key to invoke the "Information" function.

<F8> This key returns you to the "PRESETS" form.

6.3 Hierarchical Structure of COM 266

The Figure below illustrates the hierarchical structure of COM 266. The diagram shows the names of all screen forms; forms for which there are subordinate screen forms are outlined in bold type.

Functions or additional screen forms are invoked via the function keys (see Figure 6-6).

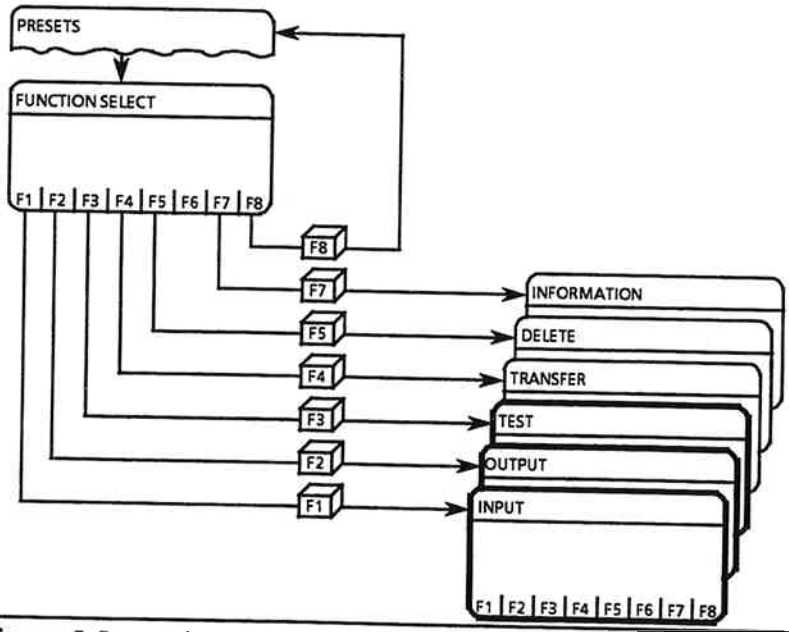


Figure 6-6. Hierarchical Structure of the "FUNCTION SELECT" Menu and Subsequent Screen Forms

And what now?
Now you must decide which function you want to select.
If you have just installed the module, start with the "INPUT" function. This function is invoked by pressing function key <F1>. You will find detailed information on the screen forms in this group in the next section.

If the machine data and traversing programs have already been stored on the module, you can press <F3> to invoke the "Test" function (see Section 6.6).

At this point, however, you should learn how to enter machine data.

Enter the machine data prompted on your screen.

▸ <F1> takes you from the "FUNCTION SELECT" menu to the program branch for entering

⇒ The "INPUT" form is displayed.
From this form, you can branch to the screen forms for entering machine data and traversing (machining) programs.

6.4 "INPUT" Form

The "INPUT" form is a main screen form with a number of subordinate forms. Figure 6-7 shows its hierarchical structure. The "OUTPUT" form has the same hierarchical structure as the "INPUT" form.

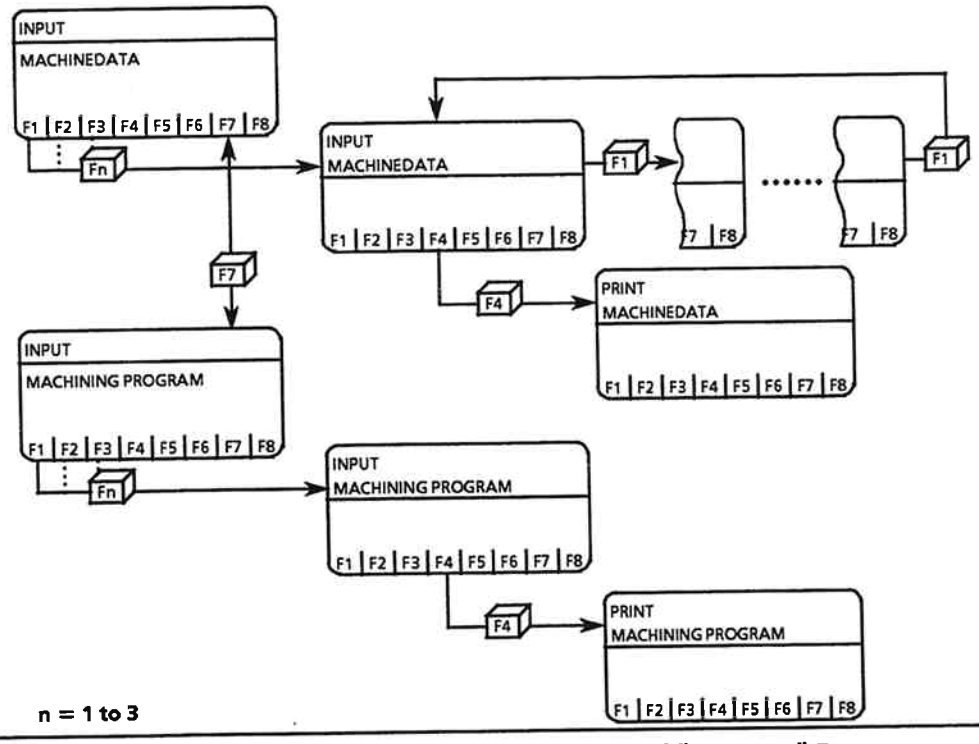


Figure 6-7. Structure of the "INPUT" and "OUTPUT" Forms

In the following, each input form is preceded by a graphic of the path to that form.

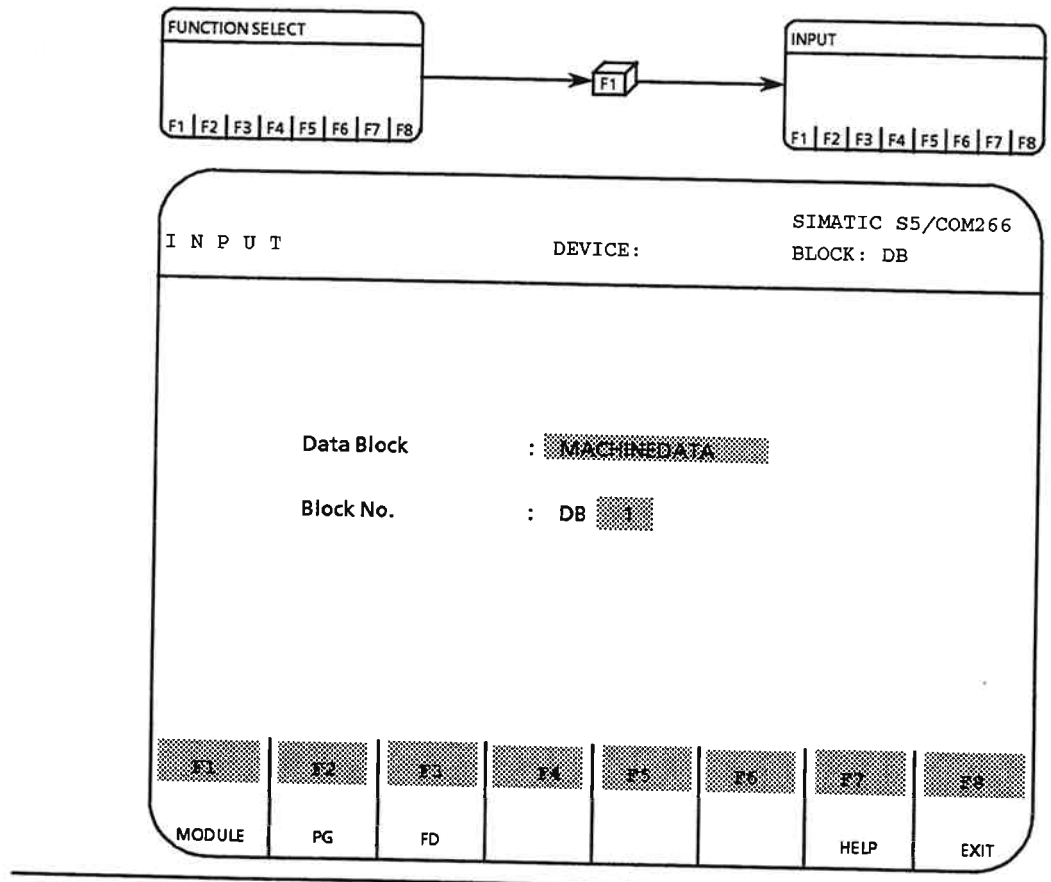


Figure 6-8. Data Block Selection

Header:
The header shows the following:

- Field 2: INPUT
- Field 5: SIMATIC S5 / COM 266
- Output fields for the target device (field 4) and the data block number (field 6). Both fields are initially blank.

Data area:

Field name	Type	Description
Data Block	I	Use <F7> to switch back and forth between MACHINEDATA and MACHINING PROGRAM.
Block No.	I	Number of the data block in which you want to store your data. Must be in the range from 0 to 255.

"Type" column: I = input field

Function key menu:
Select the data destination with function keys <F1> to <F3>.

<F1> Data destination is the IP 266.
Depending on the entry in the "Data Block" field, COM branches to the screen form for entering
- machine data or
- traversing (machining) programs

<F2> Data destination is the programmer's RAM.
COM uses the same criterion for the branch as for <F1>.

<F3> Data destination is the disk drive and file specified in the "PRESETS" form.
COM uses the same criterion for the branch as for <F1>.

<F7> Use the 'HELP' key to set the "Data Block" field to either
- MACHINEDATA
  or
- MACHINING PROGRAM

<F8> <F8> (EXIT) returns you to the "FUNCTION SELECT" menu.

And what now?

▸ Position the cursor to the "Data Block" field.
Select MACHINEDATA using <F7>.

▸ Using the cursor control keys, move the cursor to the "Block No." field. Enter there the number of the data block. Enter "1" in this field.

▸ Choose your data destination with <F1>, <F2> or <F3>.
<F3>, for instance, selects FD as data destination.
Press <F1> to choose the IP 266 as data destination.

Note:

If you have not installed an IP 266, your data destination must be either a disk drive or the programmer.

⇒ The first page of the "INPUT MACHINEDATA" form is displayed on your monitor screen.

6.4.1 Entering Machine Data

"INPUT MACHINEDATA" form (page 1)

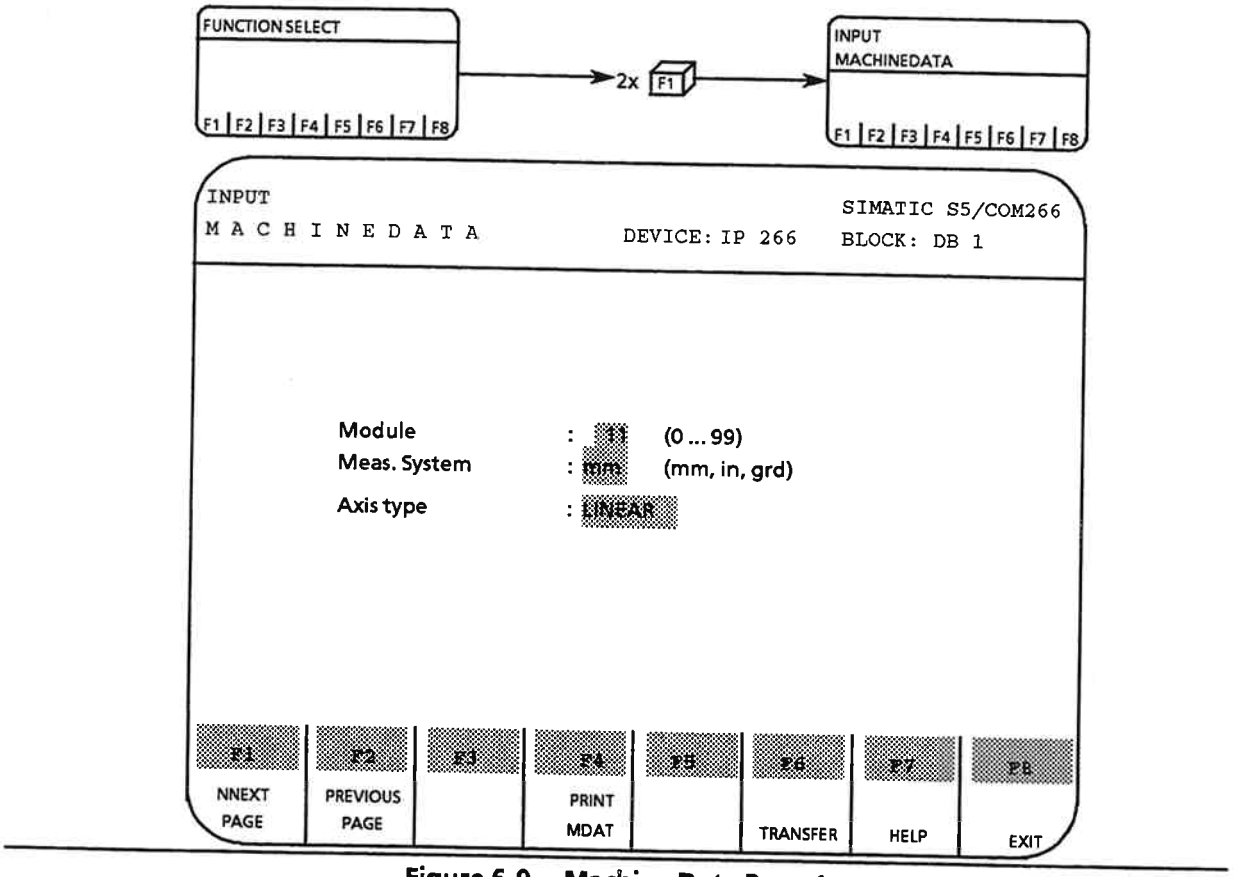


Figure 6-9. Machine Data Page 1

Header:
The header contains the following:

- Name of the screen form (fields 1 and 2): INPUT MACHINE DATA
- Name of the software package (field 5): SIMATIC S5/COM 266
- Data destination. You chose the data destination with <F1> in the "INPUT" menu. The output field shows: DEVICE: IP 266
- You also specified the number of the data block in the "INPUT" form. The output field contains the string: BLOCK: DB1.

The header is the same for all seven pages of the "INPUT MACHINEDATA" form.

Data area:

Field name	Type	Description
Module	I	You must enter a number for the module in this field. This is absolutely mandatory, as a programmable controller may be equipped with more than one IP 266. The number you enter must be in the range from 0 to 99, and must be identical to the one you entered in the "PRESETS" form.
Meas.System	I	Enter the physical unit you want to use. Use <F7> to select mm (millimeters), in (inches) or deg (degrees). The default is mm.
Axis type	I	The IP 266 supports both linear and rotary axes. Use <F7> to choose either LINEAR or ROTARY.

"Type" column: I = input field

Function key menu:

<F1> Press this key to screen the next page of the "INPUT MACHINEDATA" form. This function is possible only when you have filled in all input fields correctly.

<F2> Use this key to screen the preceding page of the "INPUT MACHINEDATA" form. This function is possible only when you have filled in all input fields correctly.

<F4> Press this key to start a printout.

<F6> Once you have filled in all input fields, you can press this key to store the machine data on the specified destination device.
The data destination is shown in the header.

Data stored on the IP 266 is first verified. Errors are flagged on the error line. When an error is detected, the page of the "INPUT MACHINEDATA" form in which the error was made is displayed on the monitor.

<F7> Use this key to choose the values for 'Meas.System' and 'Axis type'.

<F8> After confirming your intention to exit by responding to the relevant prompt with <F1>, this key returns you to the "FUNCTION SELECT" menu.

With the exception of <F7>, the function key menu is the same for all seven pages of the "INPUT MACHINEDATA" form. <F7> is included in the function key menu on pages 1, 3 and 7 only.

And what now?

- Enter 11 (the same number entered in the "PRESETS" form) in the 'Module' field.
- Set the cursor to the input field for 'Meas.System' and make your selection with <F7>. The default value for this field in [mm].
- Move the cursor to 'Axis type' and select the linear axis with <F7>. The word 'LINEAR' is displayed in the input field.
- Press <F1> to screen the second page of the "INPUT MACHINEDATA" form.

"INPUT MACHINEDATA" form (page 2)

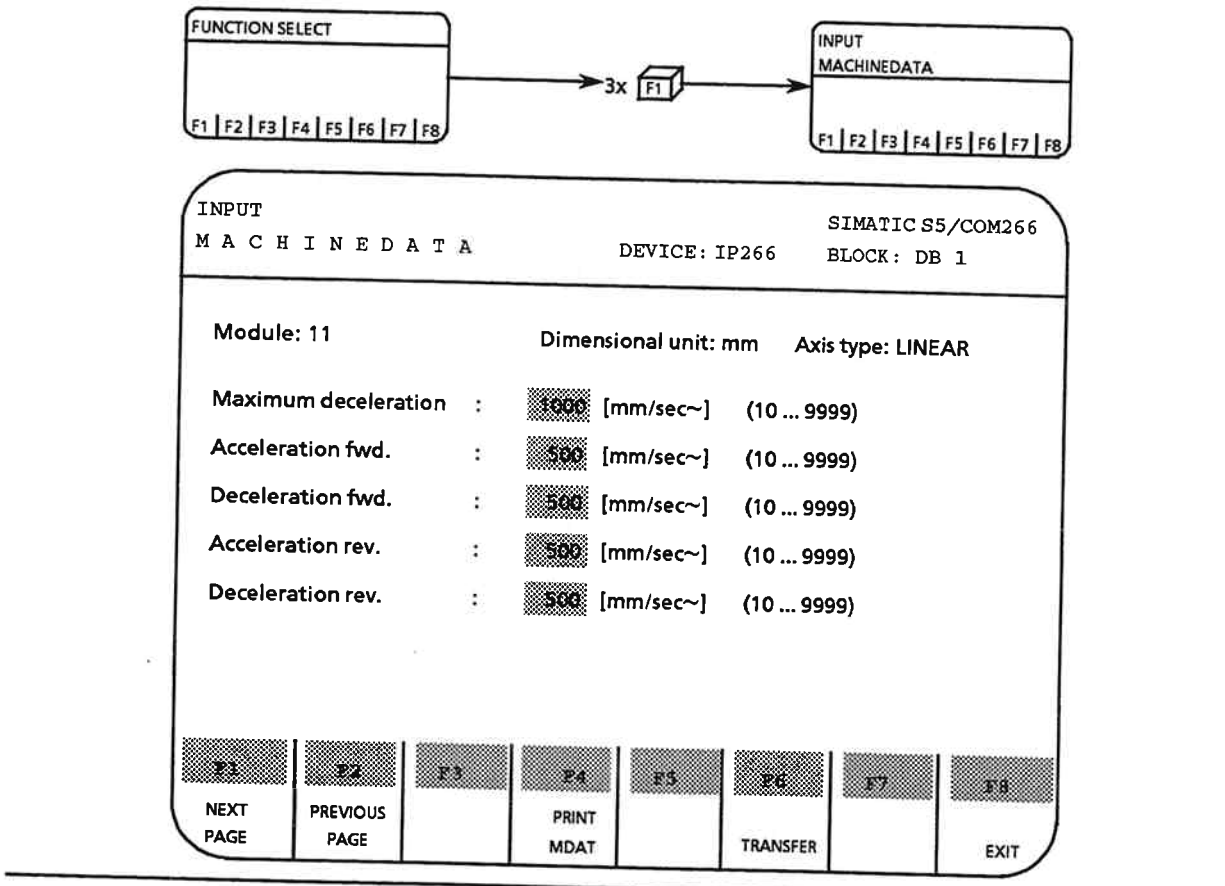


Figure 6-10. Machine Data Page 2

Header:
The header is the same as on page 1 of the "INPUT MACHINEDATA" form.

Data area:

Field name	Type	Description
Module Meas.System Axis type	O O O	These fields are the same as those on page 1 of the screen form.
Maximum deceleration	I	You must enter these data items in the appropriate fields. Remember that "Maximum deceleration" must be the highest absolute value.
Acceleration fwd.	I	
Deceleration fwd.	I	
Acceleration rev.	I	
Deceleration rev.	I	

"Type" column: I = input field, O = output field

Function key menu:
In contrast to the function key menu for page 1, the function key menu for page 2 does not contain <F7>.

And what now?
- Fill in all input fields on this page.

> **Note:**
>
> You cannot exit an input field until you have entered a value.

- Press <F1> to screen page 3 of "INPUT MACHINEDATA".

"INPUT MACHINEDATA" form (page 3)

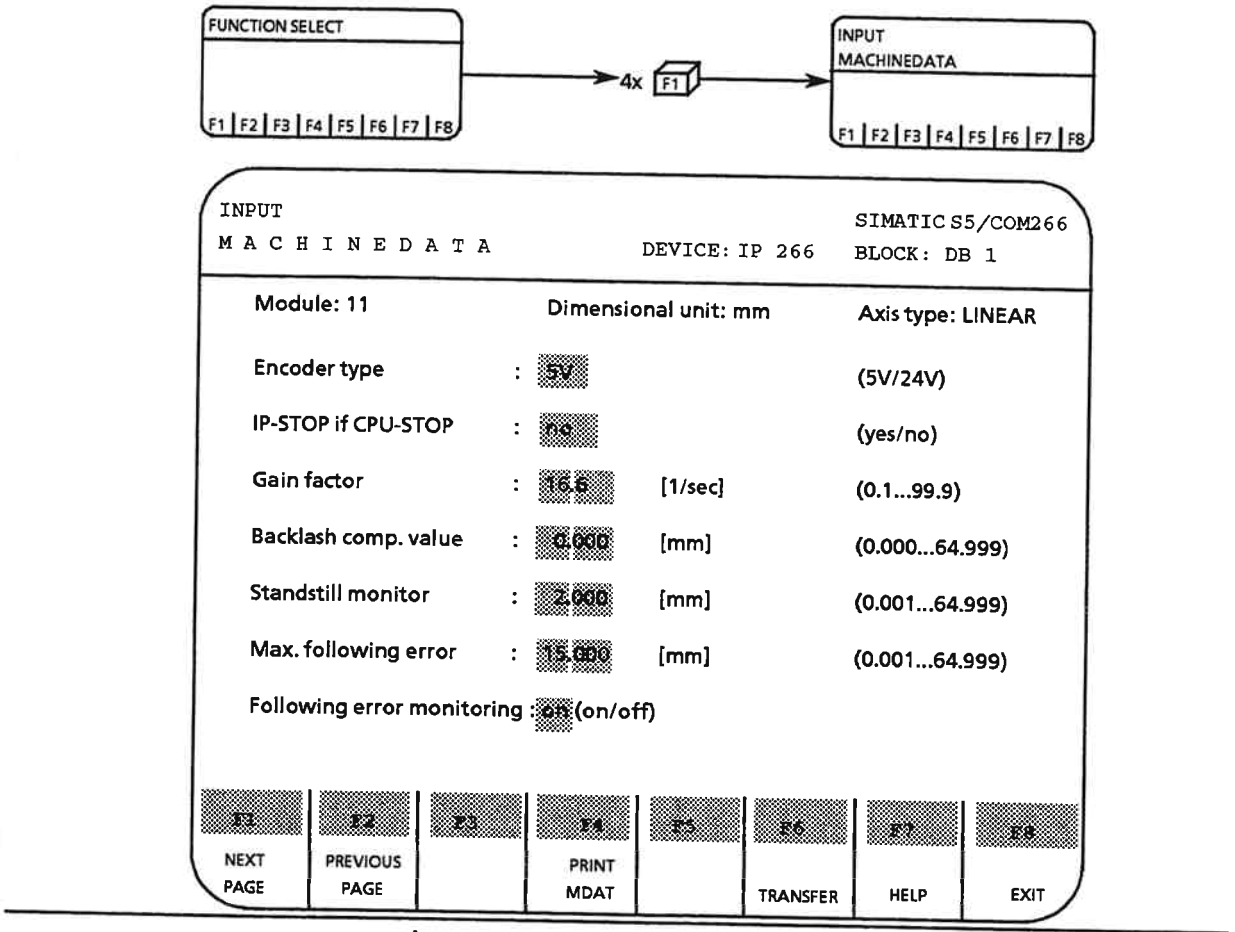


Figure 6-11. Machine Data Page 3

Header:
The header is the same as on page 1 of the "INPUT MACHINEDATA" form.

Data area:

Field name	Type	Description
Module Meas.System Axis type	O	Refer to the data area for page 2
Encoder type	I	Enter the type of encoder you are using in this field. You have a choice between two types of encoders: 5 V (symmetrical encoders) 24 V (asymmetrical encoders)
IP-STOP if CPU-STOP	I	When an error occurs during execution of the STEP 5 program, it is sometimes best to stop the IP. You can do so by entering "yes" in this field or selecting "yes" with <F7>. Active modes are interrupted with STOP. This aborts all active modes **except** mode 4.
Gain factor	I	This factor defines the gain factor for the position controller in the unit 1/sec. The permissible value range for the gain factor is from 0.1 to 99.9, although system limitations or machine data specifications (such as the resolution or the maximum speed) preclude the use of some of these values in the majority of cases.
Backlash comp. value	I	This value is added to the travel distance on each traversing (machining) movement that involves a reversal of the direction of travel, thus enabling compensation of backlash outside the control loop (drive backlash). The backlash is compensated only when there is positive mechanical coupling between drive and slide. When a reference point is approached, this may be the case immediately following the approach. Otherwise, you must program the movement yourself.
Standstill monitor	I	Maximum difference between the setpoint position and the actual position when the position controller is active. This value must be greater than zero and less than the maximum following error.
Max. following error	I	Maximum difference between the setpoint position and the actual position during traversing (machining) under closed-loop control. The maximum following error must be equal to or greater than the tolerance range of the standstill (zero-speed) monitor.
Following error monitoring	I	You can disable monitoring of the following error by entering "off" in this field or selecting "off" with <F7>. The default is "on".

"Type" column: I = input field, O = output field

Function key menu:
The function key menu is the same as that on page 1 of "INPUT MACHINEDATA".

You can use <F7> to select the appropriate value for the "Encoder type", "IP-STOP if CPU-STOP" and "Following error monitoring" fields.

And what now?

- Fill in all fields on this screen page. An input field for which there is no default can be exited only after an entry has been made.
- Press <F1> to screen page 4 of "INPUT MACHINEDATA".

"INPUT MACHINEDATA" form (page 4)

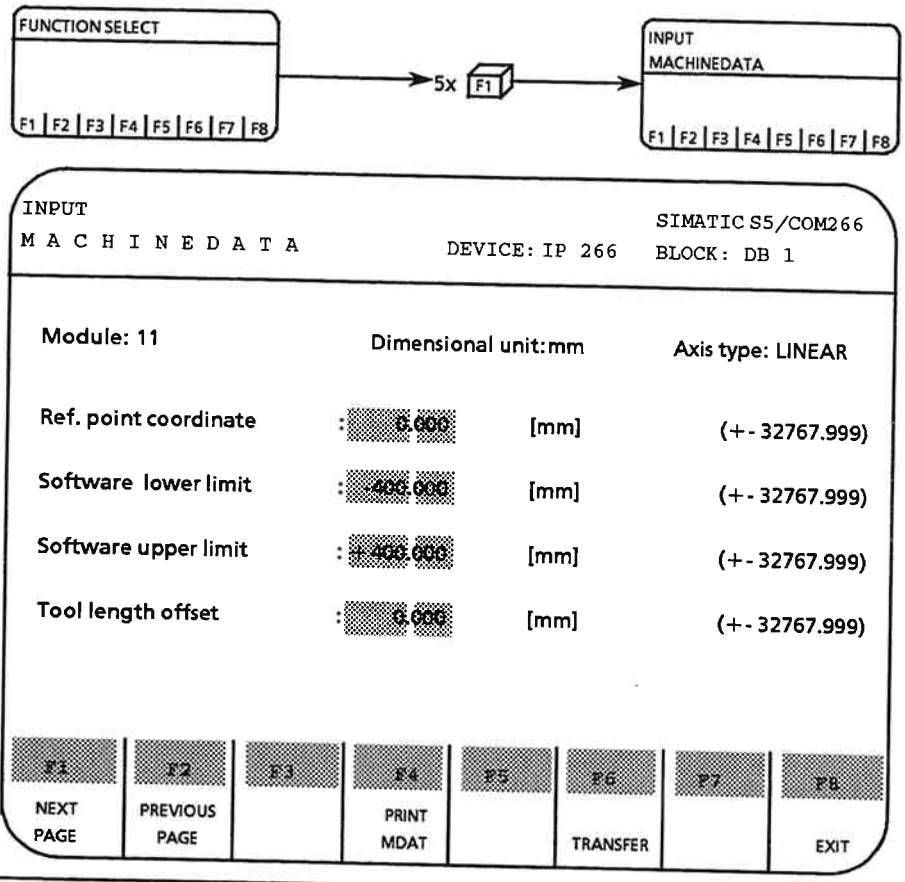


Figure 6-12. Machine Data Page 4

Header:
The header is the same as that on page 1 of "INPUT MACHINEDATA".

Data area for a linear axis:

Field name	Type	Description
Module Meas.System Axis type	O	Refer to the data area on page 2
Ref. point coordinate	I	The reference point coordinate must lie between the lower and upper software limit switches or at the exact position of one of these switches.
Software lower limit	I	This value specifies the lower software limit switch. This value must be lower than that for the upper software limit switch and must also be such that the axis cannot reach the lower hardware limit switch during deceleration.
Software upper limit	I	This value defines the coordinate of the upper software limit switch. This value must be greater than that for the lower software limit switch and must also be such that the axis cannot reach the upper hardware limit switch during deceleration.
Tool length offset	I	This value is used to compensate for tool wear. Each target position in a traversing (machining) program is offset by this value. The tool length offset is added to any previous tool offset, and can be used repeatedly.

"Type" column: I = input field, O = output field

Data area for a rotary axis:

If you are using the IP 266 to operate a rotary axis, the two fields for the software limit switches are replaced by fields for

- the start of the traversing (machining) range and
- the end of the traversing (machining) range

Field name	Type	Description
Module Meas.System Axis type	O	Refer to the data area on page 2
Ref. point coordinate	I	The reference point coordinate must lie within the traversing (machining) range or at exactly the upper or lower limit of that range.
Start of traversing (machining) range	I	This value specifies the start of the traversing (machining) range for the rotary axis, and must be lower than the value specifying the end of the traversing (machining) range.
End of traversing (machining) range	I	This value specifies the end of the traversing (machining) range for the rotary axis, and must be higher than the value specifying the start of the traversing (machining) range.
Tool length offset	I	See the table entitled 'Data Area for a Linear Axis'

"Type" column: I = input field, O = output field

Function key menu:
The function key menu is identical to that for page 2 of "INPUT MACHINEDATA".

And what now?

- Fill in all input fields on this page.
- Press <F1> to screen page 5 of "INPUT MACHINEDATA".

"INPUT MACHINEDATA" form (page 5)

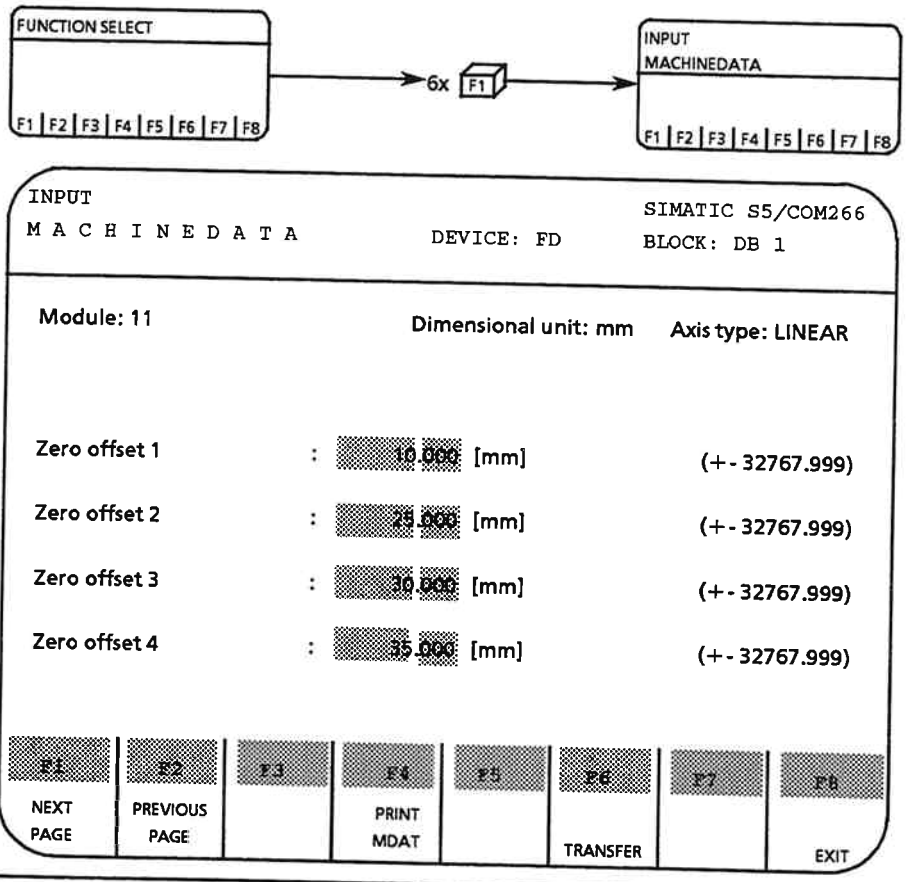


Figure 6-13. Machine Data Page 5

Header:
The header is identical to that on page 1 of "INPUT MACHINEDATA"

Data area:

Field name	Type	Description
Module Meas.System Axis type	O	You already entered the parameters for these fields on page 1.
Zero offset 1 to 4	I	Each of the four zero offsets is independent of the others, and can also be activated in traversing (machining) programs via G54 to G57. These values are added to the offsets used in modes 12 and 13. If several ZOs are used in a traversing (machining) program, they are not added; instead, they replace the existing ZOs. For instance, a zero offset set with G54 would be overwritten by a zero offset set with G56.

"Type" column: I = input field, O = output field

Function key menu:
The function key menu is identical to that on page 2 of "INPUT MACHINEDATA".

And what now?

- Fill in the fields for the zero offsets.
- Press <F1> to screen page 6 of "INPUT MACHINEDATA".

"INPUT MACHINEDATA" form (page 6)

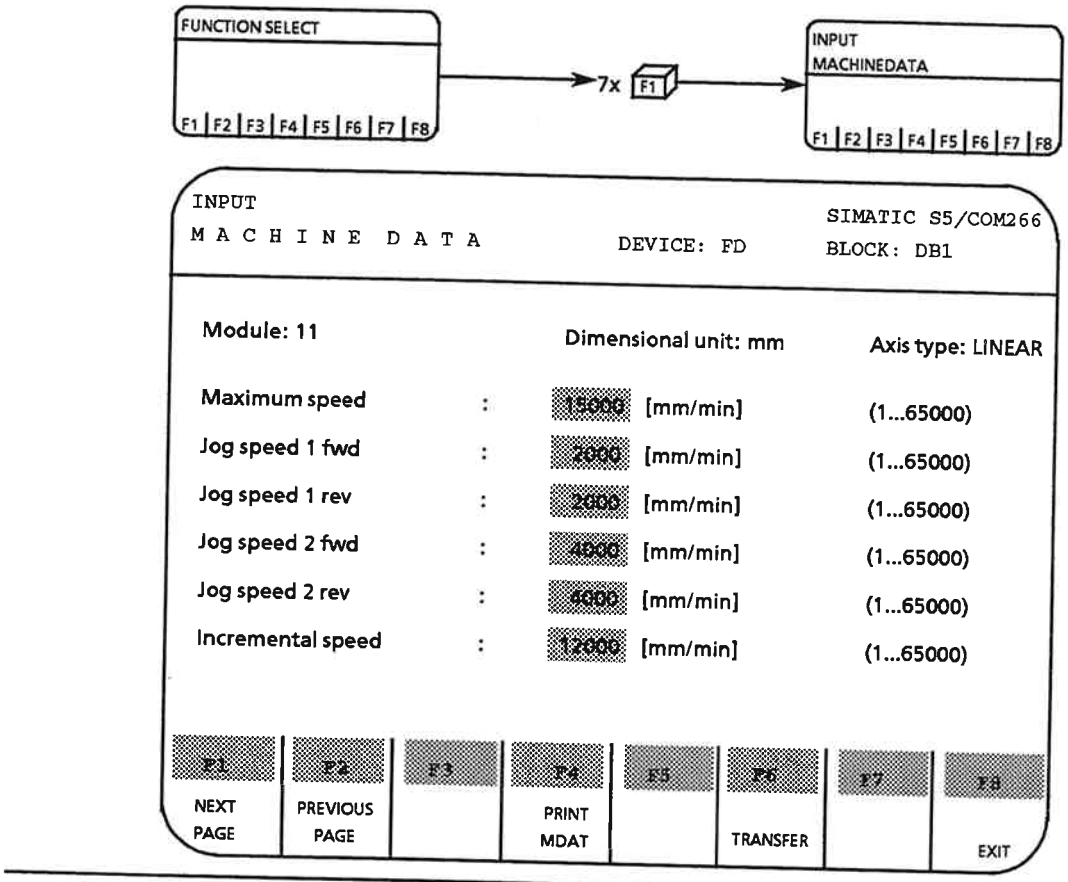


Figure 6-14. Machine data Page 6

Header:
The header is identical to that on page 1 of "INPUT MACHINEDATA".

Data area:

Field name	Type	Description
Module: Meas.System: Axis type:	O	These fields are the same as those in the data area on page 1.
Maximum speed	I	This value defines the speed at which the axis is positioned when the power section's applied voltage is 10 V. All subsequent speed specifications must be lower than or equal to the maximum speed.
Jog speed 1 fwd:	I	Speed for forward jogging in "Jog 1" mode.
Jog speed 1 rev:	I	Speed for reverse jogging in "Jog 1" mode.
Jog speed 2 fwd:	I	Speed for forward jogging in "Jog 2" mode.
Jog speed 2 rev:	I	Speed for reverse jogging in "Jog 2" mode.
Incremental speed:	I	Speed for modes 6 and 7.

"Type" column: I = input field, O = output field

Function key menu:
The function key menu is identical to that on page 2 of the "INPUT MACHINEDATA" form.

And what now?

- Enter all speed values in the appropriate fields.
- Press <F1> to screen page 7 of "INPUT MACHINEDATA".

"INPUT MACHINEDATA" form (page 7)

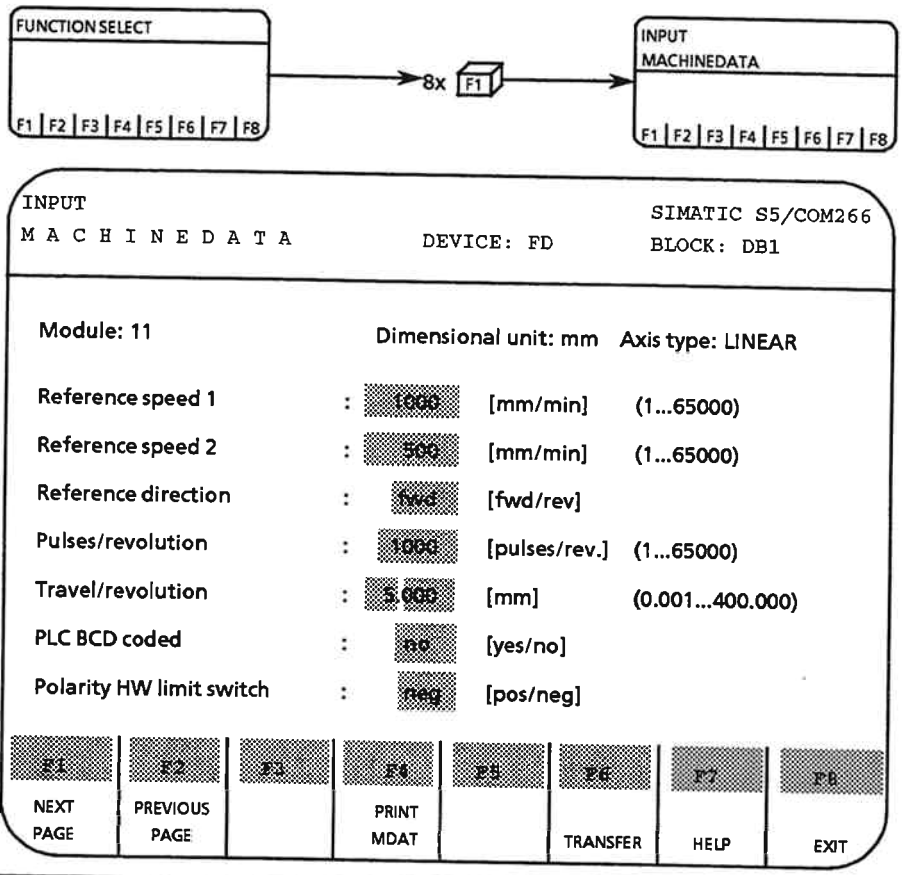


Figure 6-15. Machine Data Page 7

Header:
The header is identical to that on page 1 of "INPUT MACHINEDATA".

Data area:

Field name	Type	Description
Module: Meas.System: Axis type:	O	These fields are the same as those in the data area on page 1.
Reference speed 1:	I	The drive begins a reference point approach at this speed. Reference speed 1 is the higher of the two speeds for the initial approach to reference point, and must be less than or equal to the maximum speed.
Reference speed 2:	I	The IP 266 requires this speed for an exact approach to the reference point. Reference speed 2 must be less than or equal to the maximum speed and less than or equal to reference speed 1.
Reference direction:	I	Defines the direction for the reference point approach. Use <F7> to choose between **'forward'** and **'reverse'**.
Pulses/ revolution:	I	Specifies the number of pulses per encoder revolution (this information can be obtained from the encoder's rating plate).
Travel/ revolution:	I	The distance traversed per encoder revolution must be entered in this field. The value must take into account all ratios between encoder and axis.
PLC BCD coded:	I	When you select "yes" with <F7>, all coordinates transferred from the PLC are interpreted in BCD code. The value range in BCD format is restricted to +/- 9999999 µm.
Polarity HW limit switch:	I	This field is used to indicate which edge of the limit switch or "External Stop" signal is to be evaluated.

"Type" column: I = input field, O = output field

The "travel/pulses" resolution is computed from the values for "travel/revolution" and "pulses/revolution"

Function key menu:
With the exception of <F7>, the function key menu is identical to that on page 1 of this screen form.

<F7> is used to select predefined texts for the following input fields:
- Reference direction
- PLC BCD coded
- Polarity HW limit switch

And what now?

- Fill in all input fields.

⇒ You have now entered all machine data.

- Press <F6> to transfer the machine data to its destination.

⇒ "Active" appears briefly on the error line.

Additional function keys in the "INPUT" menu:

- You can output any page of the screen form to your printer by pressing <F4> (Print Screen function). Before attempting to start a printout, be sure that you initialized the printer with S5-DOS.

- You can screen through all pages with <F1> or <F2>, and make changes if necessary. You can forward your changes to the data destination while on any page with <F6>.

- Press <F8> when you want to return to the "FUNCTION SELECT" menu. You must confirm your request to exit with F1.

Printing out the machine data

The following print menu is displayed when you start a printout by pressing <F4>:

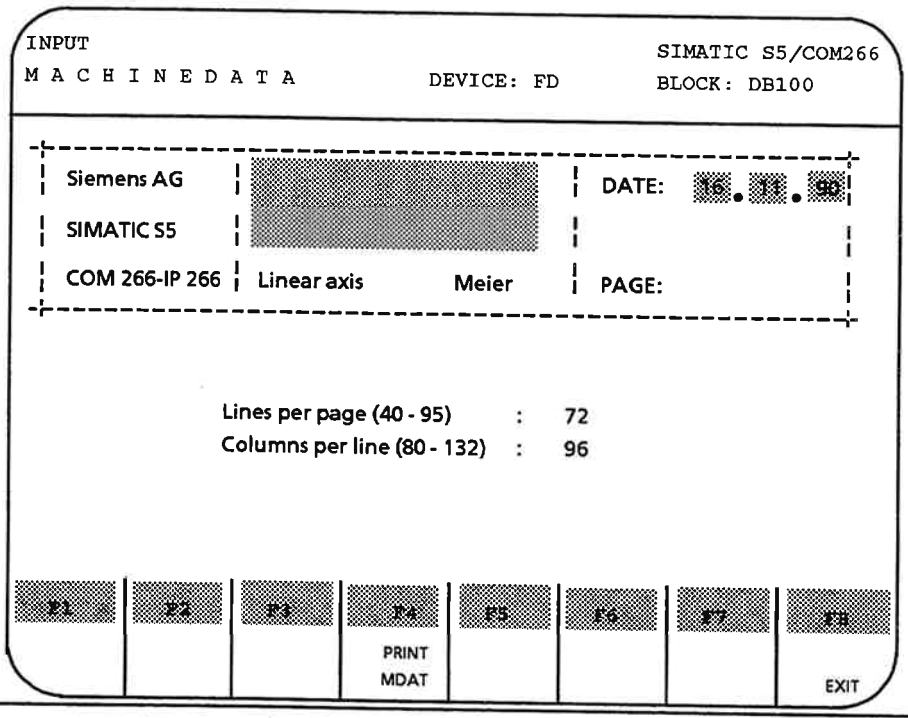


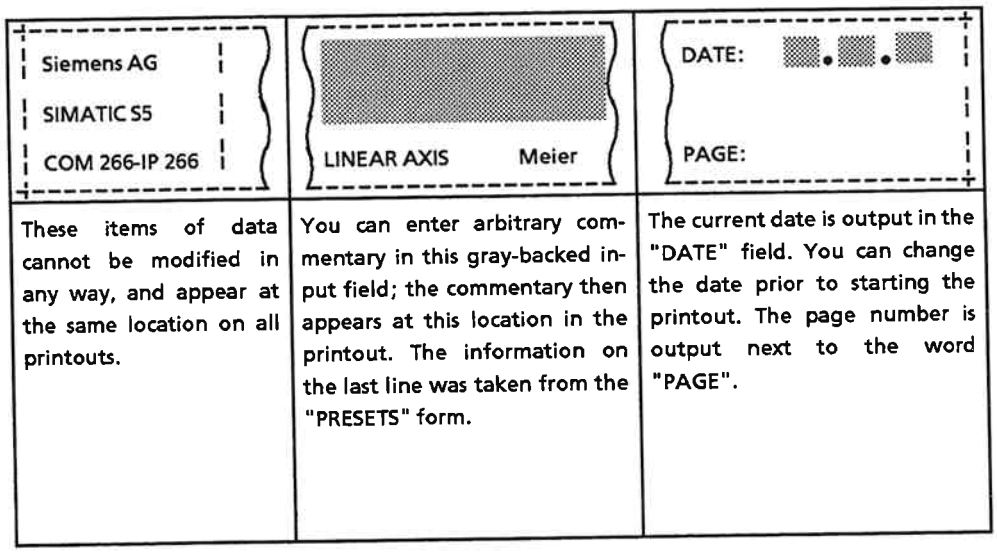
Figure 6-16. Print Form

Header:

The header is taken from the screen form in which you selected the Print function.

For example, if you are in the "INPUT MACHINEDATA" form and press <F4>, the header for the printout is taken from that screen form.

Data area:
The entries you make in the upper portion of the data area indicate how you want to end your printout. The information entered in this area is printed out at the end of the machine data or traversing (machining) program listing.



These items of data cannot be modified in any way, and appear at the same location on all printouts.	You can enter arbitrary commentary in this gray-backed input field; the commentary then appears at this location in the printout. The information on the last line was taken from the "PRESETS" form.	The current date is output in the "DATE" field. You can change the date prior to starting the printout. The page number is output next to the word "PAGE".

In the lower portion of the data area you will find two fields for initializing the printer. The fields can be changed only with S5-DOS.

"Lines per page (40-95)":	The specified number of lines per page is shown in this field.
"Columns per line (80-132)":	The specified number of columns per line is shown in this field.

Function key menu:

<F4> Press this key to start the printout.
⇒ The following message is displayed on the error line while printing is in progress:
FEC Printing ...
⇒ When the printer stops, you will see the message:
FEE Printed!

<F8> This key has two functions.
While a printout is being made, you can abort it by pressing this key. When you do so, "Abort printing (Y/N) ?" is displayed on the error line. You must either confirm the abort request by entering Y or revoke it by entering N.
If you press this key when the printer has stopped, you immediately exit the Print menu.

A machine data printout has the following layout:

Machinedata LINEAR	Source FD	DB no. 1	Module 11	Dimensional unit mm

Maximum deceleration : 500 [mm/sec~] (10...9999)

Acceleration fwd : 200 [mm/sec~] (10...9999)

...

...

...

Incremental speed : 1000 [mm/min] (10...9999)

Siemens AG Simatic S5 COM 266 - IP 266	Printout Machinedata LINEAR AXIS Meier	Date 16.11.90 Page 1

Figure 6-17. Machine Data Printout

6.4.2 Entering Traversing (Machining) Programs

The structure of traversing (machining) programs corresponds in all essentials to a subset of the DIN 66 025 standard. The programs comprise a sequence of ASCII characters, and may not exceed 1023 characters in total.

COM 266 stores traversing (machining) programs in data blocks. These blocks are distinguished from one another by a data block number. Each data block generated by COM 266 contains precisely one traversing (machining) program. COM 266 enters the data block number in the traversing (machining) program's header as program number. The total number of data blocks may not exceed 250. Data block numbers must be in the range from 0 to 255.

Traversing (machining) programs can be written in two modes of representation:

- To DIN 66 025
- In Text mode

In addition, mode 10 ("TEACH-IN") allows you to generate traversing (machining) programs automatically.

Please refer to Section 5.4 for more detailed information on traversing (machining) programs.

Entering a traversing (machining) program

- Press <F1> in the "FUNCTION SELECT" menu to screen the "INPUT" form. You are already acquainted with this screen form from your "experiments" with the "Input Machinedata" function.
- Fill in the two input fields as follows:

  Data block : Traversing (machining) PROGRAM
  Block-No. : DB 2

- Press <F1>, <F2> or <F3> to select the destination for your data (e. g. <F3> for disk drive).

⇒ You are now in the "INPUT MACHINING PROGRAM" form.

"INPUT MACHINING PROGRAM" form

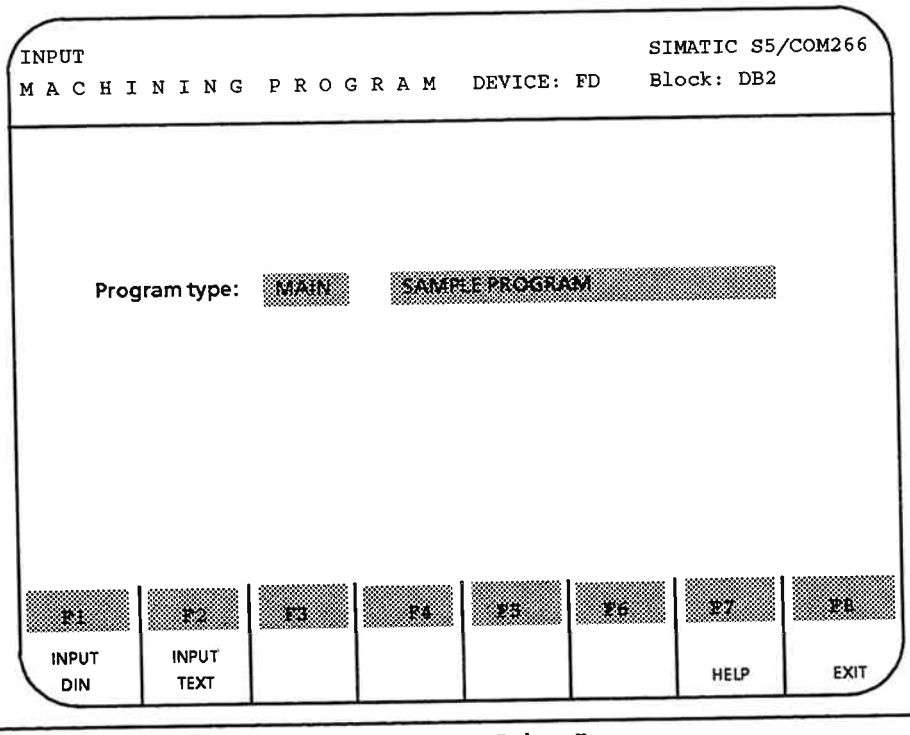


Figure 6-18. Program Type Select Form

Header:
The header shows the names of the screen form and the software package. The "DEVICE" and the "BLOCK" are taken from your entries in the "INPUT" form.

"DEVICE" identifies the data destination. This data is stored in data block DB 2 ("BLOCK: DB2").

Data area:
The input field for "Program type" is subdivided into two sections, the first of which is for entry of the program type. Using <F7>, you can choose between

- MAIN for a main program and
- SUB for a subroutine

In the second part of the input field, you can enter an arbitrary text as commentary.

Function key menu:

<F1> Press this key when you want to enter traversing (machining) programs to DIN.

<F2> Press this key if you want to enter traversing (machining) programs in Text mode.

<F7> Use this key to choose "MAIN" or "SUB" in the first section of the "Program type" field.

<F8> Press this key to exit the screen form.

And what now?

- Select the program type and enter a commentary.
- Press <F1> to enter programs to DIN.
- Press <F2> to enter programs in Text mode (optional).

- Entering programs to DIN
  The following screen form is displayed when you press <F1> in the "INPUT MACHINING PROGRAM" form:

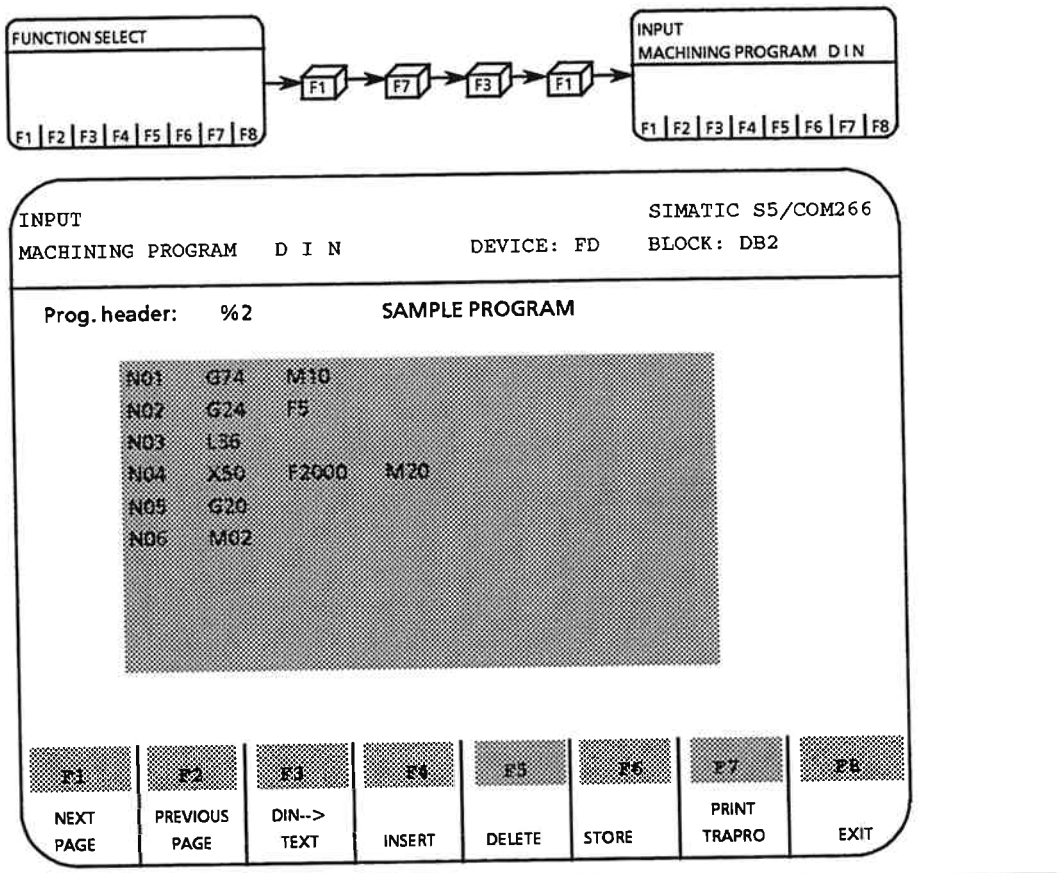


Figure 6-19. Traversing (Machining) Program Form to DIN with Sample Program

Header:
The header is taken from the Program Selection form.

Data area:
The program header for the traversing (machining) program is displayed on the first line in the data area.

"%2 SAMPLE PROGRAM" identifies a main program stored in DB2. "SAMPLE PROGRAM" was entered in the preceding screen form as commentary.

The remaining lines in the data area are for the program itself. Only one block may be entered on each line. Refer to Section 5.4 for more detailed information on the structure of traversing (machining) programs and the blocks of which they are comprised.

When you have reached the last line in the data area, the screen is scrolled up one line.

Function key menu:

<F1> If the last page of the traversing (machining) program has not yet been reached, use this key to page down.

<F2> Use this key to page up.

<F3> Press this key to change from "DIN" to "TEXT MODE". When you press this key, the cursor must be located in a line containing a complete, correct block.

<F4> Press this key to insert a blank line above the line containing the cursor.

<F5> Press this key to delete the line containing the cursor.

<F6> Press this key to forward a syntactically correct traversing (machining) program to the selected destination device. The data block is assigned the number shown in the header, which is identical to the program number in the first line of the data area. If a traversing (machining) program with this number already exists, you are prompted to indicate whether or not you want to overwrite the old file. If you reply in the affirmative, the old file is overwritten.

<F7> Press this key to output the traversing (machining) program to printer.

<F8> Press <F8> to exit the screen form.

- Entering traversing (machining) programs in Text mode
  The following screen form, in which only one block may be entered, is displayed when you press <F2> in the "INPUT MACHINING PROGRAM" form.

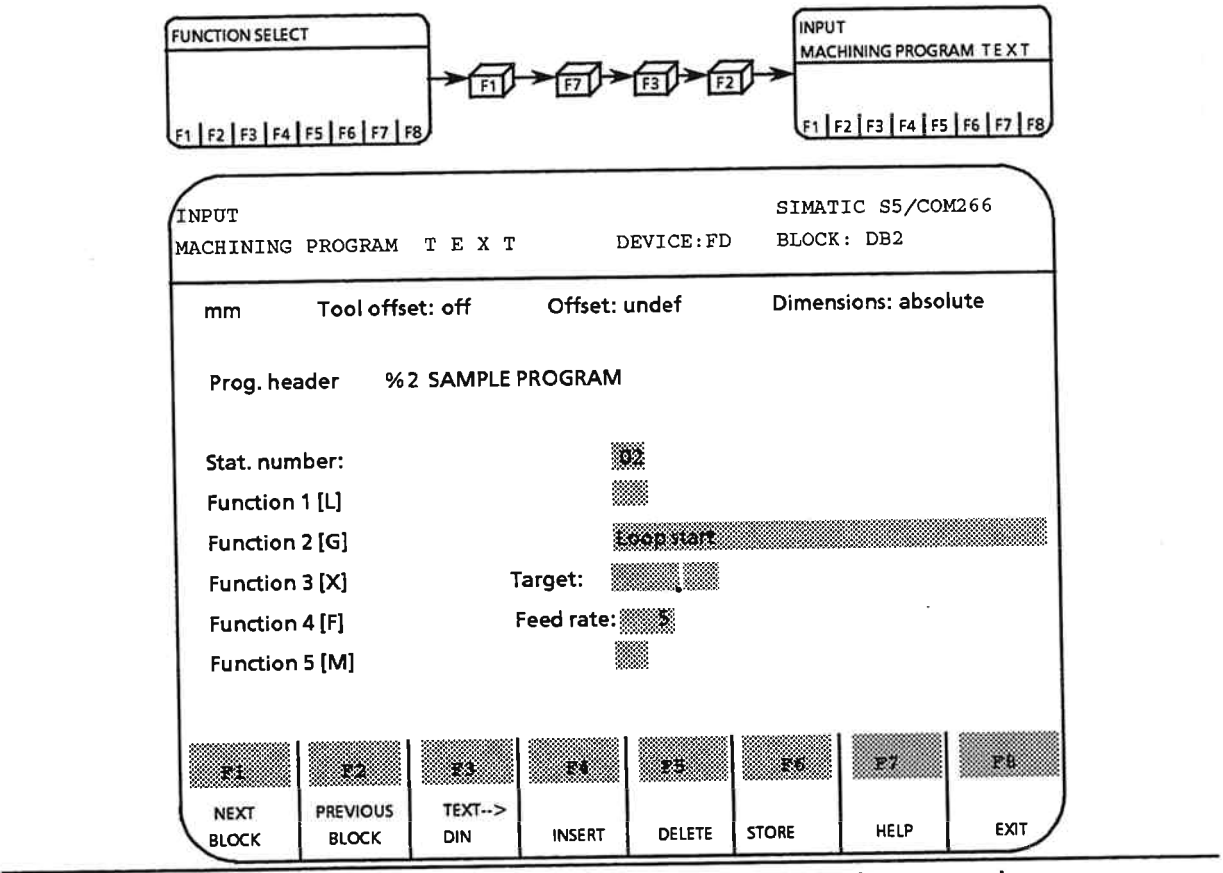


Figure 6-20. Traversing (Machining) Program Form in Text Mode

Header:
The header is taken from the Program Selection form.

Data area:

Field name	Type	Description
	O	The current physical unit is displayed in the first output field. This unit is applied to all distances and speeds. • "mm" can be selected via G70 • "0.1 in" can be selected via G71 In the course of a traversing (machining) program, the unit can be changed as often as necessary via G70/G71.
Tool offset	O	The tool offset status is displayed in this field. • "off" can be selected via G40 • "negative" can be selected via G44 • "positive" can be selected via G43 The sign of a value is not displayed in this field.
Offset	O	This field shows the number of the last zero offset. • "undef" can be selected via G53 • "1 on" can be selected via G54 • "2 on" can be selected via G55 • "3 on" can be selected via G56 • "4 on" can be selected via G57
Dimensions	O	The numerical values of the target functions (X functions) can be interpreted as either absolute or incremental values. G70 Absolute G71 Incremental
Program header	O	%2 SAMPLE PROGRAM
Stat. number (Block number)	I	Enter the block number as a numerical value in this field. A block number may comprise up to three digits. Block numbers need not be entered in ascending order. The blocks are processed in the order in which they are entered, without regard to the block number.
Function 1 [L]	I	Enter a number in this field when you want to invoke a subroutine. If an entry is made in this field, the text "Subroutine no." is displayed.
Function 2 [G]	I	Press <F7> to display the available G functions. An error message is displayed if you enter any G function not in this list.
Function 3 [X]	I	Enter a target position in this field. How this target position is interpreted depends on the entry in the "Dimensions" field.

"Type" column: I = input field, O = output field

<table>
<tr><th>Field name</th><th>Type</th><th>Description</th></tr>
<tr><td>Function 4 [F]</td><td>I</td><td>The contents of this field depend on the preceding function in the traversing (machining) block.
<table>
<tr><th>If the preceding function is...</th><th colspan="3">... the following is displayed:
Text | Value | Unit</th></tr>
<tr><td>an X function</td><td>Feed rate:</td><td>400</td><td>mm/min</td></tr>
<tr><td>G04</td><td>Dwell time</td><td>1000</td><td>msec</td></tr>
<tr><td>G24</td><td>Loop pass:</td><td>5</td><td></td></tr>
</table></td></tr>
<tr><td>Function 5 [M]</td><td>I</td><td>An M function is output at the beginning of a block.
<table>
<tr><th>Function</th><th colspan="2">Output
Text | Number</th></tr>
<tr><td>M00
M02
M99</td><td>Program stop
Program end</td><td>00
02
99</td></tr>
<tr><td>M01 and
M03 to M98</td><td></td><td>01 or
03 to 98</td></tr>
<tr><td colspan="3">No further blocks may be appended following an M02 function.</td></tr>
</table></td></tr>
</table>

"Type" column: I = input field

Function key menu:

<F1> Page down through the blocks to the end of the program.

<F2> Page up through the blocks to the beginning of the program.

<F3> Press this key to switch to "DIN" mode.

<F4> Press this key to insert a new block in front of the block that is currently on screen.

<F5> Press this key to delete the on-screen block.

<F6> Press this key to forward a syntactically correct traversing (machining) program to the specified destination device. The destination data block is assigned the number shown in the header, which is identical to the program number in the first line of the data area.

If a traversing (machining) program with this number already exists, you are prompted to indicate whether or not you want to overwrite the old file. If you reply in the affirmative, the old file is overwritten.

<F7> Use this key to select a G function.

<F8> Press this key to exit the screen form without storing the data.

And what now?

- Enter a traversing (machining) program. Before doing so, select either
  DIN mode by pressing <F1>
  or
  TEXT MODE by pressing <F2>.

- Forward the traversing (machining) program to the specified destination device (FD, PG, IP 266) with <F6>.

- Exit the screen form with <F8>. You must confirm your intention to exit by pressing <F1>.

⇒ The "FUNCTION SELECT" menu is displayed.

You have now generated machine data and a traversing (machining) program.

- If you entered your data directly on the IP 266 (target device: IP 266), you can now invoke the "TEST" function. The description of this function begins in Section 6.6.

- If you stored your data on the floppy or programmer, you must first forward it to the IP 266 before continuing. You will find details on how to do so in the next section.

6.5 Transferring an Existing Machine Data Record or a Traversing (Machining) Program

Once you have generated machine data in the programmer or on floppy disk, you can load it into the IP 266 with the "Transfer" function.

- Press <F4> in the "FUNCTION SELECT" menu to select the "Transfer" function.

This function allows you to transfer machine data or traversing (machining) programs from a source to a destination device.

The "TRANSMIT" (TRANSFER) form is displayed on the programmer screen.

> **Note:**
>
> The "Transfer" function can be invoked only when the axis status is "stopped" (i. e. "finished").

Exception:
When an operation is aborted with "Error in position control loop", the machine data can be edited and forwarded to the IP with <F6> with mode 4, even when the axis status is "traversing".

"TRANSMIT" (TRANSFER) form

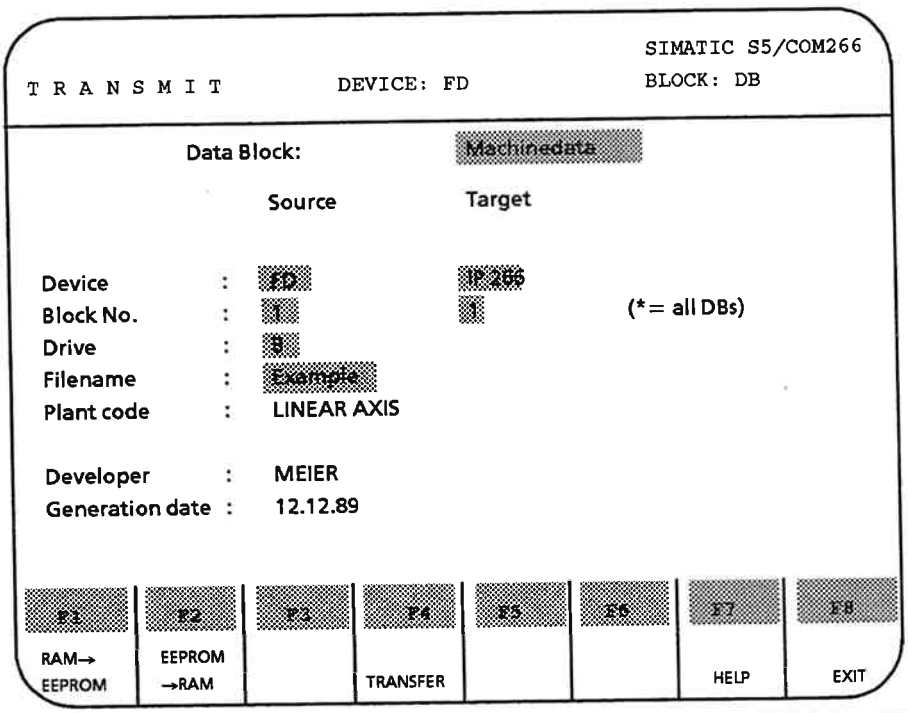


Figure 6-21. "TRANSFER" Form

Some of the fields in the header are initially blank. The current values are not entered in these fields until you have started the "Transfer" function by pressing <F4> in the "TRANSMIT" (TRANSFER) form.

This is taken into account in the following description of the fields in this screen form.

Header:

- The header is as follows before you start the "Transfer" function by pressing <F4> in the "TRANSMIT" form:
  The word "TRANSMIT" is shown as the name of the screen form.
  The name of the software package is the same as in all screen forms.
  The DEVICE field is blank, as is the field "BLOCK: DB".

- While the "Transfer" function is executing, the name of the screen form is supplemented by either "MACHINEDATA" or "MACHINING PROGRAM" in field 2 of the header, depending on your entries in the data area of the "TRANSMIT" form.

  The "DEVICE" field now shows the source device and the "BLOCK" field the number of the data block you want to transfer. Field 2 of the header indicates whether machine data or traversing (machining) programs are being transferred.

Data area:

Before starting the transfer, you must enter

- the source and
- the destination.

These values are displayed when the transfer function has been started.

"Data Block" field: Before starting the Transfer function, select either MACHINEDATA or MACHINING PROGRAMS with <F7>. When the Transfer function is started, your selection is displayed in the header as supplement to the name of the screen form.

Field	Source	Destination
Device:	Select one of the following with <F7>: • Module/IP 266 • Programmer/PG • Disk drive/FD The next selection is displayed each time you press <F7>.	
DB No.:	Enter the number of the data block you want to transfer.	The source data block is displayed as default. You may change this number.
	An asterisk (*) in this input field automatically selects all "traversing (machining) program" DBs. "*" is also allowed for transferring machine data from FD to FD.	The DB no. of the destination device is irrelevant.
Drive:	If the DEVICE is a floppy disk or hard disk, you will be prompted to specify the drive. Make the appropriate selection with <F7>.	The drive identifier is taken from the "PRESETS" form, and cannot be changed.
Filename:	If you selected a drive, you must enter the filename in this field. Select a file from the list of files on the relevant drive with <F7>. "Data block missing" is displayed if no file is available.	The name specified in the "PRESETS" form is displayed as filename, and cannot be changed.
Plant code Developer Generation date	The "Plant code", "Developer" and "Generation date" fields are updated in accordance with the file selected.	

Function key menu:
If the IP is disconnected from the mains power, or if a power failure occurs, the data in its RAM is lost, and must therefore be stored on EEPROMs before the IP is actually put into operation in the plant. This applies to both machine data and traversing (machining) programs. On IP start-up, this data is transferred to IP RAM. The EEPROM has a maximum storage capacity of 8 Kbytes, only 7K of which is available for traversing (machining) programs. The remaining capacity is needed for machine data and housekeeping routines.

<F1> Press this key to transfer the data currently on the module to EEPROM. This data may include machine data and/or programs.

<F2> Before the data stored on EEPROM can be used, it must be transferred to the IP's RAM. The IP 266 normally makes this transfer automatically in its restart routine. If you want to retransfer data from EEPROM to RAM (because the data in RAM has been modified, for instance), you can do so by pressing <F2>.

<F4> Press this key to start the transfer you defined in the data area of this screen form.

<F7> This key is used as selector key for the following input fields:
"Device:"
"Drive:"
"Filename:"

<F8> This key terminates the "TRANSFER" function and returns you to the "FUNCTION SELECT" menu.

And what now?
Machine data must be available on the IP 266 before you can proceed to the "TEST" form.

If no valid machine data is in the IP's RAM, you must forward this data to the IP 266 from the programmer, disk or EEPROM.

- Select the source device and the number of the data block containing the machine data.
- If your source is a disk, enter the drive and the name of the source file.
- Select the IP 266 as destination.
- Start the transfer with <F4>.
- Press <F8> to return to "FUNCTION SELECT".

If you have not yet generated machine data, please do so. You will find details on this procedure in Section 6.4.1.

If your machine data is on EEPROM, transfer it to the IP's RAM with <F2>.

6.6 COM 266 Test Mode

COM's Test Mode allows you to test the interplay between the IP 266 and the mechanical elements of the drive in all modes.

> **Caution**
>
> If your system has just been installed, please follow the steps below in order.

Prerequisites:
- The programmer must be interfaced to the IP 266.
- The programmer must be in "ON LINE" mode. You can change the programmer mode by pressing <F2> in the "PRESETS" form.

▸ Start the "Test" function by pressing <F3> in the "FUNCTION SELECT" menu.

⇒ The "TEST" form is displayed.

Figure 6-22 shows the hierarchical structure of the "TEST" form.

There are two "TEST" modes:
When the "TEST" function is invoked, COM 266 is in the "Actual-value display" mode. The default operating mode is the "FOLLOW-UP" mode (mode 4). This mode has not been started, however. The output fields in the data area are not yet updated.
The second "TEST" mode is "Mode Select". In this mode, you can make changes in the screen form's input fields.

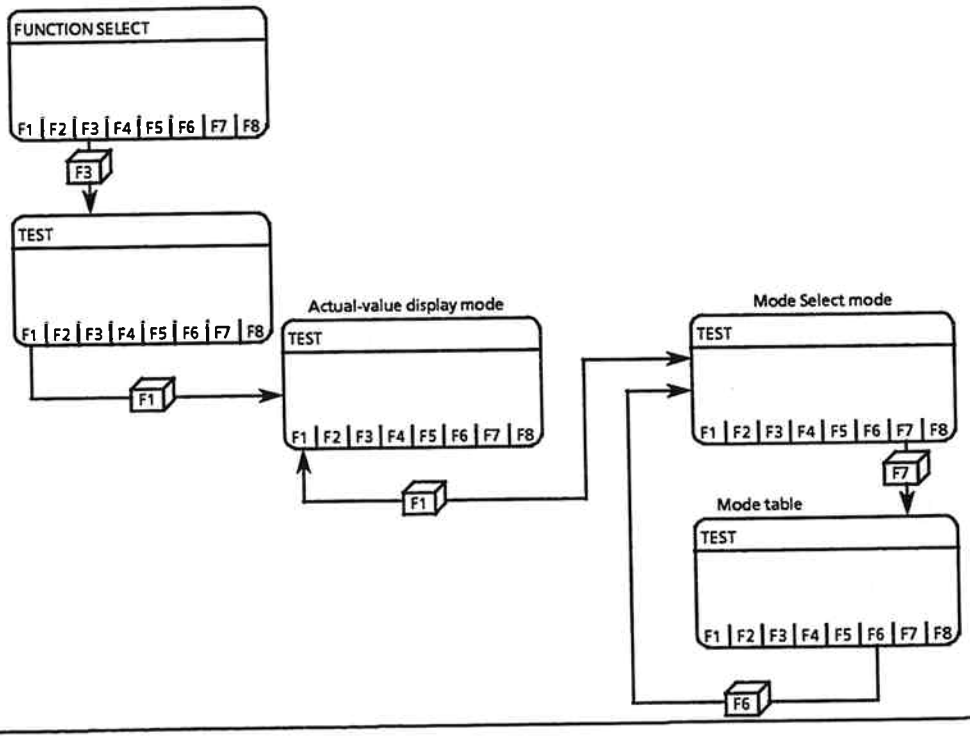


Figure 6-22. Hierarchical Structure of the TEST Form

And now?

- Once you have become acquainted with the two "TEST" form modes, you can begin your first test.
- The two "TEST" modes are described in detail in Sections 6.6.1 and 6.6.2.

6.6.1 "Actual-Value Display" Mode

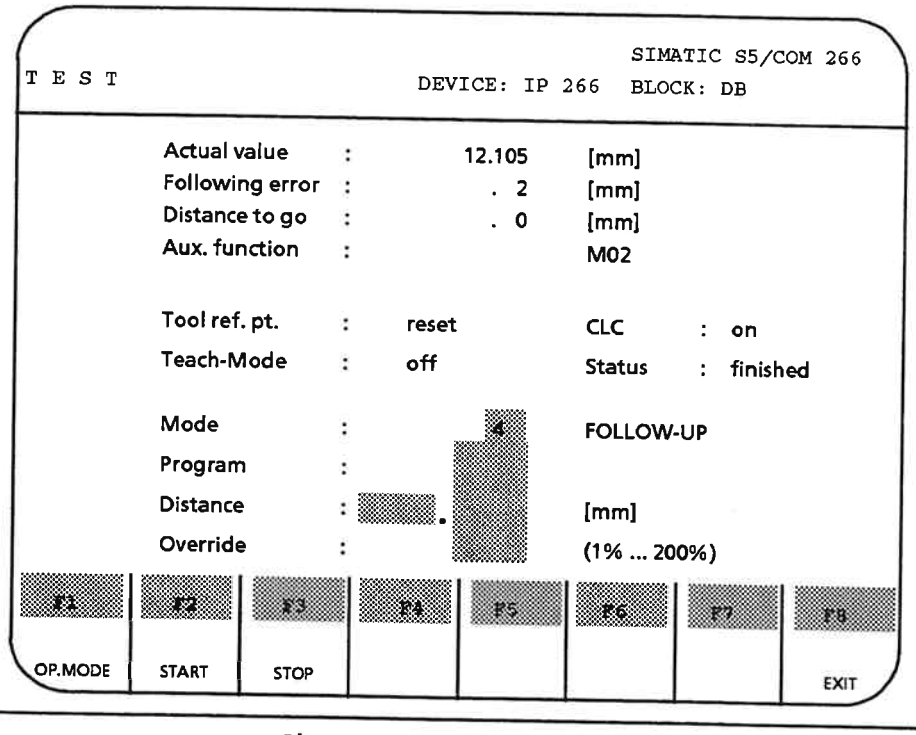


Figure 6-23. "TEST" Form

In this "TEST" mode, the IP 266 provides the current actual position, following error/speed, distance to go and switching functions.

These values are recomputed and redisplayed at regular intervals.

Header:
Header field 2 shows the name of the on-screen form, which consists only of the word "TEST", in spaced type, until you have invoked an operating mode (Figure 6-23). Field 1 is initially blank, and is not filled in until you have started a mode (see Section 6.3.3).

> **Note:**
>
> COM 266 automatically generates mode 17 (reset errors) when you exit the "TEST" form with <F8>. When "TEST" is reinvoked, "START ERROR RESET" is displayed in field 2 and the name of the "TEST" form in field 1.

Field 5 shows the name of the software package, i. e. SIMATIC S5/COM 266. IP 266 is displayed in field 4 ("DEVICE"), and the text "BLOCK: DB" in field 6.

Data area:

Field name	Type	Description
Actual value:	O	The current position of the axis is displayed in this field. The basis for the display is the specified dimensional unit.
Following error:	O	The difference between the actual position and the setpoint position is displayed in this field. The upper limiting value is defined in the machine data parameter "Max. following error" (see Section 5.1.6).
Speed:	O	In modes 3 and 4, "Following error" is replaced by "Speed". This field shows the actual speed computed by the IP 266.
Distance to go:	O	When a mode is started with absolute or relative target position specification, the IP 266 computes the distance between the target position and the current position of the drive. During traversing, the continually changing value is displayed in this field.
Switching function:	O	M functions may be programmed in a traversing (machining) program. When mode 8 or 9 is started in a traversing (machining) program, the programmed M functions are displayed in this screen form field.
Tool ref. pt.:	O	The word "set" appears in this field when mode 5 has executed. The word "reset" is displayed if there is no reference point.
CLC:	O	This field shows the controller status. "On" is displayed in all modes except 3 and 4. "Off" is displayed in modes 3 and 4.
Teach-Mode:	O	The word "on" is displayed in this field when a traversing (machining) program is generated in mode 10. The word "off" appears only when mode 10 is terminated with mode 11.
Status:	O	finished: No mode has been started. As soon as the zero-speed monitor is tripped during a traversing movement, the displayed changes from "running" to "finished". running: A mode has been started and is still in progress.
Mode Program Distance Override	O	In "actual-value display" mode, these fields are static output fields, and are used to display the specified mode and all parameters.

"Type" column: O = output field

Overview of the output fields in the "TEST" form

Table 6-2 provides an overview of TEST" form output fields

- following error
- distance to go and
- aux. function

and their use in the various modes.
The "following error" is replaced by the "speed" in the open-loop control modes.

Table 6-2. Mode-Dependent Output Fields

Mode	Following error	Speed	Distance to go	Aux. function
1	•			
2	•			
3		•		
4		•		
5	•			
6	•		•	
7	•		•	
8	•		•	•
9	•		•	•
10	•			
11	•			
12	•			
13	•			
14	•			
15	•			
16	•			
17	•			
18	•			
19	•			

Function key menu:

<F1> Press this key to screen the "Mode Select" form. The actual-value display is "frozen" to the current value. The "Mode", "Program", "Distance" and "Override" fields become input fields, and the cursor is set to the start of the "Mode" field.

<F2> ... <F6> These keys are mode-dependent. Refer to Table 6-3 in Section 6.6.2 for a key-to-mode assignment list.

<F8> Press this key to exit the "TEST" form and screen the "FUNCTION SELECT" menu. COM 266 generates mode 17 when you press this key.

And what now?

▸ The "TEST" form's "Mode Select" subform is described in detail in the next section.

6.6.2 "Mode Select" Mode

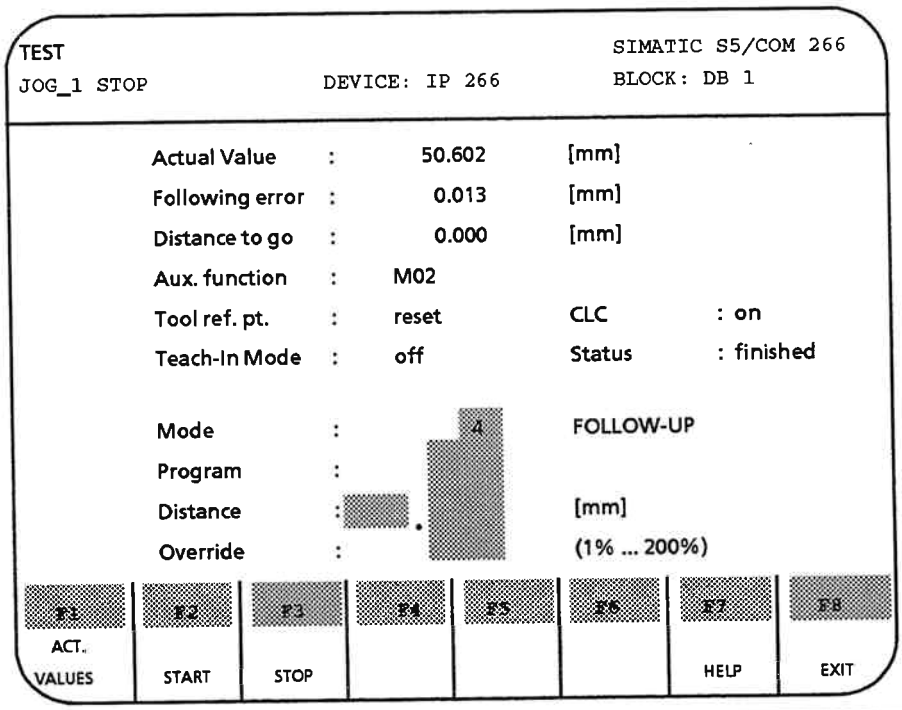


Figure 6-24. Mode Select Form

Header:

The header is identical to that for the "Actual-Value Display" mode of this screen form.

Data area:

Field name	Type	Description
Actual value, distance to go, following error	O	These fields show the actual values that were on screen at the instant at which the mode was changed.
Aux. function	O	The last M function activated is displayed in this field, or "255" if no M functions were invoked (in the PLC: KH format= "FF", KF format= "1"). M02 is output following termination of a traversing (machining) program.
Mode	I	Enter the number of the required mode in this field. The mode number must be in the range from 1 to 19. The mode identification text is displayed at the right of this number. Press <F7> to screen a list of all modes (1 to 19). The display for mode 5 differs from that of the other modes in that an additional input field is provided at the right of the mode identification text; using <F7>, you can set this field to either "set" or "approach".
Program	I	Enter the number of a traversing (machining) program in this field for modes 8, 9 and 10.
Distance	I	An entry must be made in this field for modes which require a distance specification for an absolute or relative positioning operation, a zero offset or a tool offset.
Override	I	The speed for a positioning operation can be modified by entering an override factor in this field (for modes 1 to 7). The positioning speed can also be altered during traversing. The override factor must be forwarded to the IP with <F6>.

"Type" column: I = input field, O = output field

Function key menu:
The function key menu in this screen form is mode-dependent. Table 6-3 shows the allocation of the five commands "Start", "Stop", "Forward", "Reverse" and "Transfer" to modes 1 to 19.

Table 6-3. Function Keys <F2> to <F6> in Modes 1 to 19

Mode	F2 Start	F3 Stop	F4 Forward	F5 Reverse	F6 Transfer
1 Jog 1		●	●	●	●[1]
2 Jog 2		●	●	●	●[1]
3 Jog open loop		●	●	●	●[1]
4 Follow-up mode	●	●			
5 Reference point approach	●	●			
6 Incremental absolute	●	●	●*	●*	●[1]
7 Incremental relative		●	●	●	●[1]
8 Automatic	●	●			●[2]
9 Autom. single statement	●	●			●[3]
10 Teach-In on	●				
11 Teach-In off	●				
12 Zero offset absolute	●				
13 Zero offset relative			●	●	
14 Clear zero offset	●				
15 Tool offset			●	●	
16 Tool offset off	●				
17 Delete error	●				
18 Drift compensation	●				
19 Drift compensation off	●				

* Rotary axis only
1 The current speed can be modified via the override factor when the axis is "traversing (machining)" (axis status "running").
2 Acknowledge an M00 function (programmed stop)
3 Execute next block

Auxiliary screen form for Mode Select

Different modes require different entries in the "TEST" form's input fields. Table 6-4 shows the allocation of input fields to modes.

Table 6-4. Input Fields for Modes 1 to 19

Mode	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Program								•	•	•									
Distance/Target						•	•					•	•		•				
Override	•	•	•			•	•												

• Entry required for this mode

Selecting a mode

If you do not know the number of the mode you want to select, press <F7> (HELP) to screen a mode list.

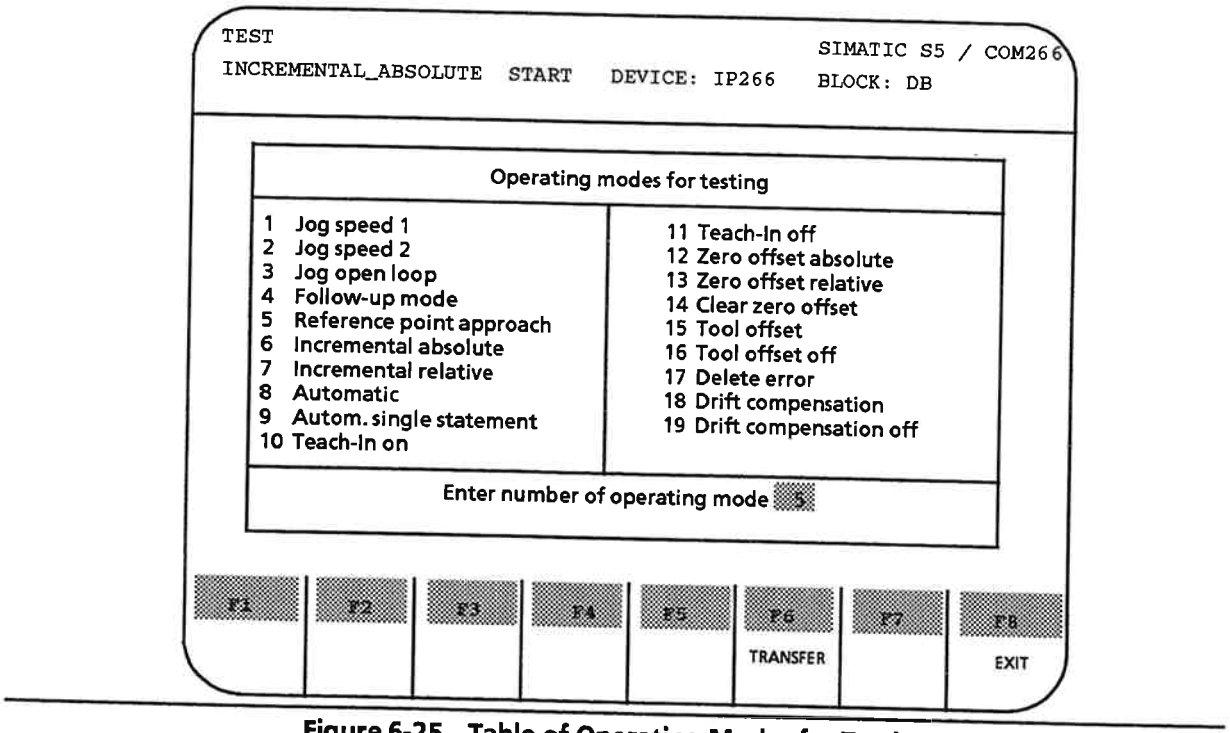


Figure 6-25. Table of Operating Modes for Testing

The Help menu lists all modes and their numbers.

Header:

The header does not change when you screen the Help menu.

Data area:

The data area comprises a single input field. After viewing the mode list, enter the number of the mode you want in this field.

Function key menu:

<F6> Press this key to transfer the mode number you entered in the Help menu to the 'Mode' field in the "TEST" form.

<F8> Press this key to exit the Help menu without transferring the mode number to the "TEST" form.
The mode always defaults to 4 when you exit Help with <F8>.

And now?

- Practice using the TEST forms.
  Enter various different modes and view the changes in the data area and the function key menu.

You have now familiarized yourself with the COM 266 screen forms and menus you need to start with. The remaining screen forms, which are also invoked in the "FUNCTION SELECT" menu, are described in detail in the following subsections.

6.7 Output

The "Output" form is invoked by pressing function key <F2> in the "FUNCTION SELECT" menu. This screen form allows you to display machine data or traversing (machining) programs on the programmer. Press <F1>, <F2> or <F3> to select the data source:

<F1>: IP 266
<F2>: Programmer (PG)
<F3>: FD

The structure of the "Output" form is the same as that of the "INPUT" form shown in Figure 6-7.

"OUTPUT" form

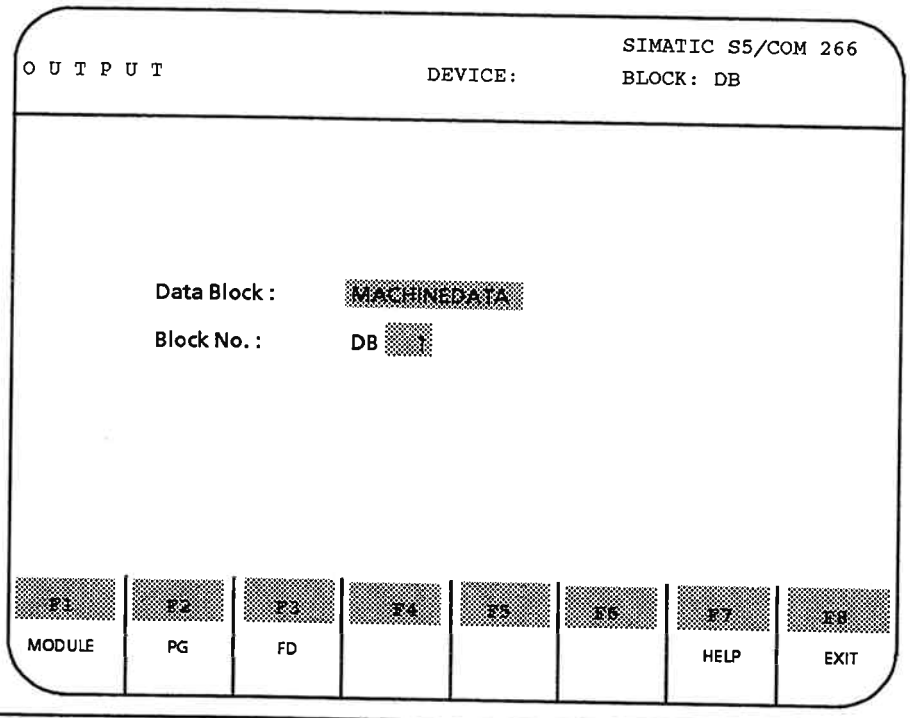


Figure 6-26. Block Selection

The structure of each "OUTPUT" form is identical to that of the corresponding "INPUT" form; the only difference is the name of the form shown in the header.

The data display begins when you have pressed <F1>, <F2> or <F3>.

- Output machine data
  The seven screen form pages of machine data are displayed when you entered MACHINEDATA in the 'Data Block' field or selected MACHINEDATA with <F7>.

  The data on each screen page is identical to that on the corresponding page of the "INPUT MACHINEDATA" form. All fields are input fields, i. e. the data in these fields can be overwritten. You can store and print out your new data.

- Output traversing (machining) program
  You can display your traversing (machining) program by entering MACHINING PROGRAM in the 'Data Block' field or by selecting MACHINING PROGRAM with <F7>. You can edit the program and store any changes made.

6.8 Delete

- Screen the "DELETE" form by pressing <F5> in the "FUNCTION SELECT" menu.

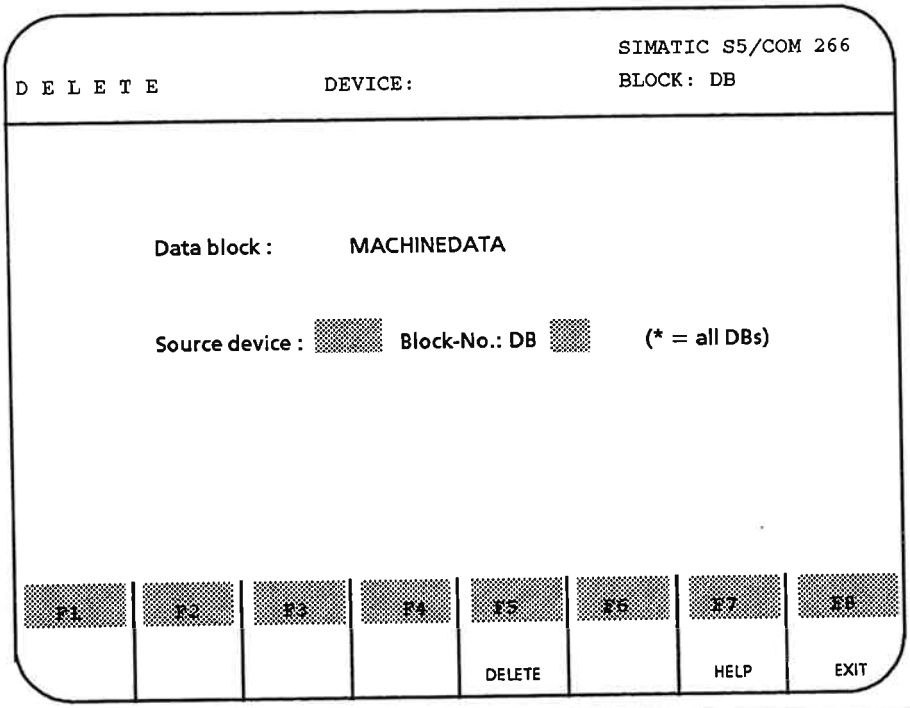


Figure 6-27. "DELETE" Form

Header:

- Prior to first-time execution of the "DELETE" function:
  You will see only the word "DELETE" as screen form name.
  The "DEVICE" field is initially blank, as is the "BLOCK" field.

- Machinedata" or "Traversing (machining) Program" appears in the header while the "DELETE" function is executing, depending on your entry in the data area of the screen form. The "DEVICE" field now shows the identifier of the device on which data is being deleted, and the "BLOCK" field the number of the data block. The screen form name, which is now complete, indicates what is being deleted (machine data or traversing (machining) programs).

- Further delete operations
  Each time a new Delete operation is started, the header shows the information for the preceding Delete.

Data area:

You must specify the following before executing the "DELETE" function:

- The type of data block
- The device on which data is to be deleted
- The number of the data block to be deleted

Field name	Type	Description
Data block	I	Use <F7> to select either "MACHINEDATA" or "MACHINING PROGRAM".
Source device	I	This field is used to select the device on which data is to be deleted. Use <F7> for cyclic enabling of the source devices.
Block No.: DB	I	Enter the number of the data block to be deleted in this field or enter "*" to delete all existing DBs.

"Type" column: I = input field

Function key menu:

<F5> When you have specified the file you want to delete, press this key to start the Delete operation. The output fields in the header are updated. A prompt is displayed on the error line asking you whether you are sure you want to start the Delete operation. If you confirm with <F1>, the word "Deleted" appears to show you that the Delete operation has been successfully completed.

Entry of a non-existent file is flagged by an error message.

<F7> Use this key in the "Data block" field to choose between "MACHINEDATA" and "MACHINING PROGRAM".

<F8> Use this key in the "Data block" field to choose between "MACHINEDATA" and "MACHINING PROGRAM".

6.9 Information

You can invoke this function to screen an overview of all machine data or traversing (machining) programs stored on the IP 266, FD or PG.

This function is invoked by pressing <F7> in the "FUNCTION SELECT" menu.
⇒ The data area of the "INFORMATION" screen form is blank when this function is invoked.

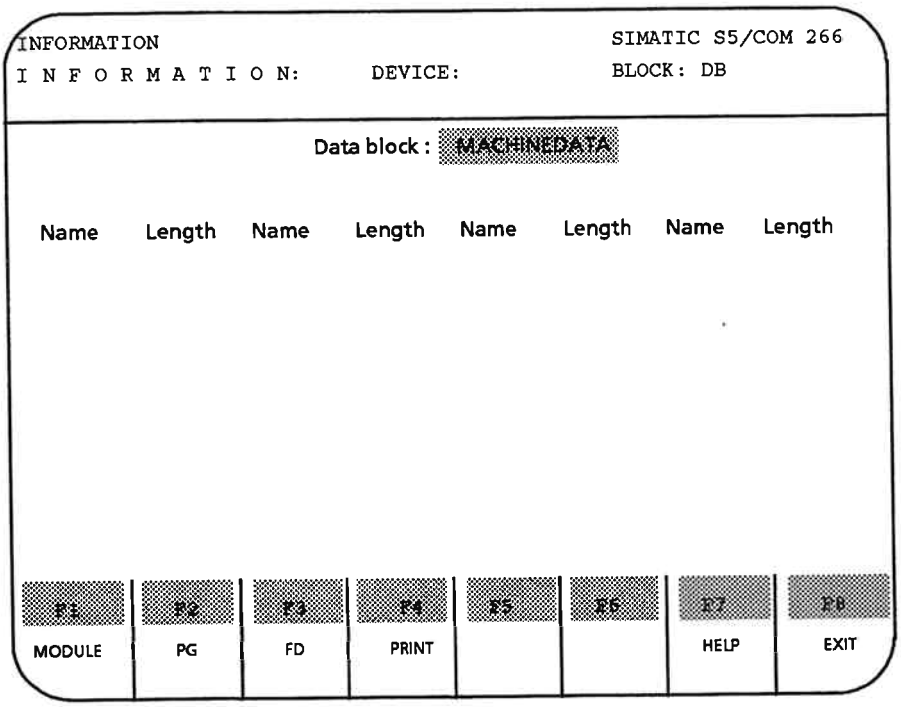


Figure 6-28. "INFORMATION" Form with Blank Data Area

Header:
The header contains the following information:

- Screen form name: INFORMATION
  I N F O R M A T I O N
- Name of the software package: SIMATIC S5/COM 266
- "DEVICE" field
  The contents of this field depend on which key you press to start the function (i. e. <F1>, <F2> or <F3>).

Data area:
Until you have selected a device, no filenames are displayed in the data area and the cursor is set to the screen form's only input field.

Choose between MACHINING PROGRAM and MACHINEDATA.

The portion of the screen form beneath the line

Name Length Name Length Name Length Name Length

is not filled in until the device has been selected.

Example:

- Press <F7> in the "FUNCTION SELECT" menu to invoke the Information function.
- The text MACHINEDATA is displayed in the 'Data block' field. Press <F3> to select a disk drive (FD) as source.

⇒ All data blocks on the source device that contain machine data are listed in the data area. You specified the disk drive in the "PRESETS" form.

Function key menu:

<F1> The Information function outputs the IP 266's data directory.

<F2> The Information function outputs the programmer's data directory.

<F3> The Information function outputs the numbers of the data blocks on the disk.

<F4> This key is added to the function key menu after you have selected a device, and is used to output the data block list to printer.

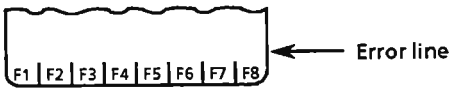
> **Note:**
>
> The printer must be on and must also have been initialized with S5-DOS.

<F7> Use this key to select the data block type, i. e.
MACHINEDATA
or
MACHINING PROGRAM

<F8> Exit and return to the "FUNCTION SELECT" menu.

6.10 COM 266 Error Messages

In all COM 266 screen forms, one line is reserved to display error codes and the corresponding error messages.



These messages provide information on incorrect parameters or parameter syntax errors and problems relating to a positioning operation or to the hardware. Once an installation has been correctly initialized, any error messages normally relate directly to positioning operations or to the limits of the traversing (machining) range. These errors are flagged in the "TEST" form and on the PLC.

An error message can be cleared by starting a new mode in which that error cannot occur or by invoking mode 17.

When an error message has occurred and the COM 266 test mode is exited, the error message is cleared on both the programmer and the PLC.

Note:

When the test mode is exited, COM 266 invokes mode 17.

7 Communication Between the CPU and the IP 266

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7 Communication Between the CPU and the IP 266

The IP 266 can be plugged into slots 0 to 7 of the S5-100U programmable controller. Eight bytes are reserved in both the process input (PII) and process output (PIO) image for each slot. The CPU and the IP 266 use all eight bytes of the PII and the PIO to interchange data. Please note that the IP 266 requires version 6ES5-100-8MA02, or a newer version, of the CPU 100.

In this manual, an interchange of data is referred to as a "frame". From the STEP 5 point of view, there are two types of "frames":

Data interchange: PLC CPU→ IP 266 Output frame
Data interchange: IP 266→ PLC CPU Input frame

Table 7-1. Module Address Assignments

PS	CPU	SLOTS 0	1	2	3	4	5	6	7	8	9
Analog addresses		64 to 71	72 to 79	80 to 87	88 to 95	96 to 103	104 to 111	112 to 119	120 to 127	The slots from 8 up may not be used	

The permissible address range is from 64 to 127. The IP 266 is addressed with byte-oriented or word-oriented Load and Transfer statements, as are analog input or analog output modules.

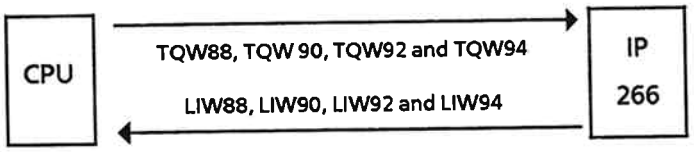


Figure 7-1. Example of Data Interchange Between CPU and IP 266 (in slot 3)

The IP 266 interchanges data with the programmable controller's CPU over the 100U bus. To make this possible, you must write operator commands to the process output image (PIO). From here, these commands are forwarded to the IP 266 once in each data cycle. A bit in byte 1 of the output frame prevents multiple execution of identical job orders.

The data in the output frame is needed to operate the IP 266, providing the IP 266 with information on

- the mode
- the parameters and
- the operations to be carried out.

Data from the IP 266 is forwarded to the PII in each firmware cycle (every 3.75 ms).

7.1 Output Frame (PLC CPU→ IP 266)

The allocation of the bytes in the output frame depends on which slot the IP 266 is plugged into in the PLC. Table 7-2 shows the allocation of the output bytes (QB) to the current slot numbers.

Table 7-2. Addressing of the Output Frame

Slot number	Byte in the output frame							
	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0	QB 64	QB 65	QB 66	QB 67	QB 68	QB 69	QB 70	QB 71
1	72	73	74	75	76	77	78	79
2	80	81	82	83	84	85	86	87
3	88	89	90	91	92	93	94	95
4	96	97	98	99	100	101	102	103
5	104	105	106	107	108	109	110	111
6	112	113	114	115	116	117	118	119
7	120	121	122	123	124	125	126	127

Table 7-3. Overview of the Output Frame

Byte	Description								Recommended data format
0	Mode codes								KF
1	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	KM
	TOGGLE	0	0	TRANS	REV	FWD	STOP	START	
2	Byte parameter for various modes								KM/KF
3	Override factor								KF
4 5	Binary-coded: 16-bit fixed-point number with sign (bit 7 in byte 4) for forwarding the integer digits in the value to the IP 266. BCD: byte 4, bits 4 to 7: sign of the BCD number byte 4, bits 0 to 3 and byte 5, bits 0 to 7: 3 BCD digits								KF KH
6 7	Binary: 16-bit binary number for forwarding the decimal digits to the IP 266. BCD: byte 6, bits 4 to 7: least-significant integer byte 6, bits 0 to 3 and byte 7, bits 0 to 7: three decimal digits in the BCD number								KF KH

7.1.1 Byte 0: Mode

Byte 0 is used for coding the modes, which you can invoke via a STEP 5 program.

To choose a mode, enter one of the mode numbers listed in the table below in byte 0 in KF format.

Mode no. in KF format	Description
1	JOG 1
2	JOG 2
3	CONTROLLED JOG
4	FOLLOW-UP MODE
5	REFERENCE POINT
6	INCREMENTAL ABSOLUTE
7	INCREMENTAL RELATIVE
8	AUTOMATIC
9	AUTOMATIC SINGLE BLOCK
10	TEACH-IN ON
11	TEACH-IN OFF
12	ZERO OFFSET ABSOLUTE
13	ZERO OFFSET RELATIVE
14	CLEAR ZERO OFFSET
15	TOOL OFFSET ON

Mode no. in KF format	Description
16	TOOL OFFSET OFF
17	ACKNOWLEDGE ERROR
18	DRIFT COMPENSATION ON
19	DRIFT COMPENSATION OFF
20	TRANSFERRING MACHINE DATA
26	RAM ↔ EEPROM
31	UNRESTRICTED SPEED SPECIFICATION
32	READING OUT THE UNRESTRICTED SPEED SPECIFICATION
33	DISABLING THE MONITORS
34	ENABLING THE MONITORS
71	READ ACTUAL POSITION
72	READ FOLLOWING ERROR
73	READ DISTANCE TO GO
99	SYNCHRONIZE IP

Note:

Mode 99 must be started before issuing the first job order.

Modes 71 to 73 are monitoring modes, and can be started in parallel to all other modes. Even while a mode is in progress, you can switch between modes 71 to 73 without affecting the process.

7.1.2 Byte 1: Commands

The commands for executing a mode depend on the mode specified in byte 0. Table 7-4 lists the permissible commands for all modes.

Table 7-4. Command Codes

Command	7	6	5	4	3	2	1	0
START	0/1	0	0	0	0	0	0	1
STOP	0/1	0	0	0	0	0	1	0
FORWARD	0/1	0	0	0	0	1	0	0
REVERSE	0/1	0	0	0	1	0	0	0
TRANSFER	0/1	0	0	1	0	0	0	0

Note:

Only one of the bits 0 to 4 may be set at any given time. An error is flagged if you set more than one of these bits, and the job request is not serviced. Bits 5 and 6 must **always** be "0".

TOGGLE bit
Bit 7 has a special function, and is used as Execute bit. A change in the value of this bit informs the IP 266 that a new job request has been issued. In this case, the IP 266 interprets the frame as a new job request.

The next job cannot be started until bit 7 once again changes its signal state, thus ensuring that a given job will not be reinterpreted and restarted in every cycle. This bit must be set to "0" in the restart OBs, thus ensuring that the first job will always be started on a change from 0 → 1.

The IP 266 scans this TOGGLE bit in each firmware cycle, and starts a new job where appropriate (see Figure 7-2).

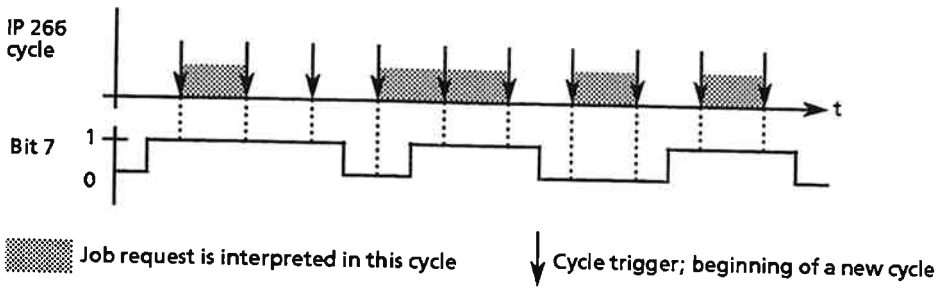


Figure 7-2. Interpreting a Job Order in Dependence on the TOGGLE Bit

Example: Give the IP 266 the Start command for the specified mode by coding byte 1 as shown below. Before the command was forwarded to the IP, bit 7 was 0.

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
1	1	0	0	0	0	1	0	0

This issues the Start command "Forward" to the IP 266. The mode is started because the TOGGLE bit (bit 7) changed from 0 to 1.

7.1.3 Byte 2: Program Number, Reference Point or EEPROM ↔ RAM Parameters

The contents of this byte depend on the specified mode.

In modes 5, 8, 9, 10 and 26, byte 2 is used as byte parameter. It is irrelevant in all other modes.

Mode	Use	KM FORMAT								KF FORMAT
		7	6	5	4	3	2	1	0	
5	Reference point: Bit 0 = 0 : approach Bit 0 = 1 : set	0	0	0	0	0	0	0	X	———
		X: variable; bit 1 to 7 irrelevant								
8 9 10	Number of the machining program	———								Example: KF = +7 Program no. 7
26	Direction of data transfer: IP EEPROM ↔ IP RAM Bit 0 = 0 : RAM → EEPROM 1 : EEPROM → RAM	0	0	0	0	0	0	0	1	———
		Example: This bit combination is used to transfer data from the IP 266's EEPROM to IP RAM, i.e. the current RAM contents are overwritten.								

7.1.4 Byte 3: Override Factor

Byte 3 is the second of the byte parameters, and contains the override factor. A valid value must be entered in this byte for all modes which allow modification of the speed via an override factor. The value must be in the range from 1% to 200%, and should be entered in KF (fixed-point constant) format if possible. The override factor is transferred in byte 1 to the IP 266 with "TRANSFER".

Example:
Assuming you want to operate your drive in mode 1 (JOG 1) with an override factor of 75%.

▸ Enter the number in byte 3 in binary (KF format).

KF = +75

Set bit 4 in byte 1 to activate the override factor during a traversing movement.

7.1.5 Bytes 4 to 7: Positioning Specifications

A number of IP 266 modes require specification of a position.
This value may be:

- an absolute target position or coordinate (see modes 6 and 12)
  or
- a relative position (see modes 7, 13 and 15)

Enter this value in bytes 4 to 7 of the output message as follows:

Table 7-5. Position Specifications

Byte	Binary	BCD
4	Sign and	Sign and the
5	integer digits	three highest integer digits
6	Decimal	First integer digit
7	digits	and 3 decimal digits

The value can be entered in one of two formats. The value range depends on the format used:
Binary: ±32767.999
BCD: ± 9999.999

Binary-coded positions
15 bits are provided for the integer portion of the number. It is thus possible to represent the number $2^{15} - 1$, or 32 767. In the case of a negative number, the integer portion is represented as two's complement. The decimal digits are specified as an absolute value.

BCD-coded positions
The sign is specified in bits 4 to 7 of byte 4. If the number is negative, bit 7, at least, must be "1". Since there are three decimal places, four decades are still available for the integer portion of the number.

	Binary (KF fixed-point constant format)	BCD (KH hexadecimal constant format)
Integer positions	Byte 4 Byte 5	Byte 4 Byte 5 Byte 6 (bits 4 to 7)
Decimal positions	Byte 6 Byte 7	Byte 6 (bits 0 to 3) Byte 7

Positions in the range 0 to - 0.999
Special rules govern the definition of a binary value between -1 and 0 (e. g. - 0.5). These values have an integer value of - 0, which cannot be represented as two's complement. When you want to specify a position in this range, you must enter the values that make up the position in the following order:

1. Enter integer position "0" as a positive value in bytes 4 and 5.
2. Enter the decimal positions as a negative number in two's complement representation in bytes 6 and 7.

A small negative number in BCD format is defined in the usual manner.

Example 1:
The drive is to be moved a distance of - 50.500 mm in "relative increment mode" (mode 7).

Position specification	Byte 4	Byte 5	Byte 6	Byte 7
Binary KF	- 50 = sign and integer positions		500 = decimal positions	
BCD KH	8005 = sign and integer positions		0500 = 1 integer and 3 decimal positions	

	Binary (KF format)		BCD (KH format)	
Integer positions	Byte 4 Byte 5	- 50	Byte 4 Byte 5 Byte 6 (bits 4 to 7)	8005
Decimal positions	Byte 6 Byte 7	500	Byte 6 (bits 0 to 3) Byte 7	0500

Example 2:
The drive is to be moved the very short distance of - 0.500 mm in "relative increment mode" (mode 7). When you enter the value in binary, you must specify the decimal digits as a negative number.

Table 7-6. Entering a Small Negative Value

Position specification		Byte 4	Byte 5	Byte 6	Byte 7
Binary	KF	0 = sign and integer positions		- 500 = decimal positions	
BCD	KH	8000 = sign and integer positions		0500 = 1 integer and 3 decimal positions	

7.1.6 Example of a Complete Output Frame

The drive is to be moved backward - 35.750 mm in "relative increment mode" (mode 7) at 20% of the incremental speed. BCD is to be used as data format.

The data formats recommended in Table 7-3 have been used in the table below for the output frame.

Output frame:

Byte	KF	KH	KM								Remarks
			Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	
0	+7		—								Mode 7
1	—	—	0/1	0	0	0	1	0	0	0	Bit 3: REVERSE command Bit 7: TOGGLE bit
2	0	—	—								Not relevant in this mode
4, 5 6, 7		8003 5750	—								Relative distance - 35.750 mm

The TOGGLE bit (bit 7) must change its value each time a command is issued. If it was 0 for the last command, you must now enter a 1.

7.2 Input Frame (IP 266 → PLC CPU)

The allocation of the bytes in the input frame depends on the slot used for the IP 266 in the programmable controller. Like Table 7-2 for the output frame, Table 7-7 shows the allocation of the input bytes (IB) to the current slot numbers.

Table 7-7. Addressing of the Input Frame

Slot number	Byte in the input frame							
	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
0	IB 64	IB 65	IB 66	IB 67	IB 68	IB 69	IB 70	IB 71
1	72	73	74	75	76	77	78	79
2	80	81	82	83	84	85	86	87
3	88	89	90	91	92	93	94	95
4	96	97	98	99	100	101	102	103
5	104	105	106	107	108	109	110	111
6	112	113	114	115	116	117	118	119
7	120	121	122	123	124	125	126	127

Table 7-8. Overview of the Input Frame

Byte	Description								Recommended data format
0	Current mode								KF
1	M function								KF
2	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	KM
	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	
	Status bits for axis, controller and machine data								
3	Current IP 266 error codes								KH
4 5	Bytes 4 to 7 are used for actual position, distance to go or following error, depending on the specified mode and on the current monitoring command.								
	Binary: 16-bit fixed-point number with sign (bit 7 in byte 4) used to forward the integer positions of the value to the IP 266. BCD: Byte 4, bits 4 to 7: sign of the BCD number Byte 4, bits 0 to 3 and Byte 5, bits 0 to 7: 3 BCD digits								KF KH
6 7	Binary: 16-bit binary number used to forward the decimal positions to the IP 266. BCD: Byte 6, bits 4 to 7: least-significant integer position Byte 6, bits 0 to 3 and Byte 7, bits 0 to 7: three decimal positions								KF KH

7.2.1 Byte 0: Mode

The IP 266 acknowledges the mode in byte 0. This value can be read in KF (fixed-point constant) format.

Example:
The IP 266 returns the mode that is currently in progress or was just executed in byte 0 of the input frame.

KF = +2

⇒ The current mode is mode 2 (JOG 2).

Note:

Neither the current monitoring mode (71, 72 or 73) nor mode 99, which synchronizes the IP 266, is acknowledged.

7.2.2 Byte 1: M Function

In modes 8 and 9, the drive is positioned via machining programs. If M functions were written in these programs, their values are entered in byte 1 when the relevant machining block is processed. The value is best read out in KF format.

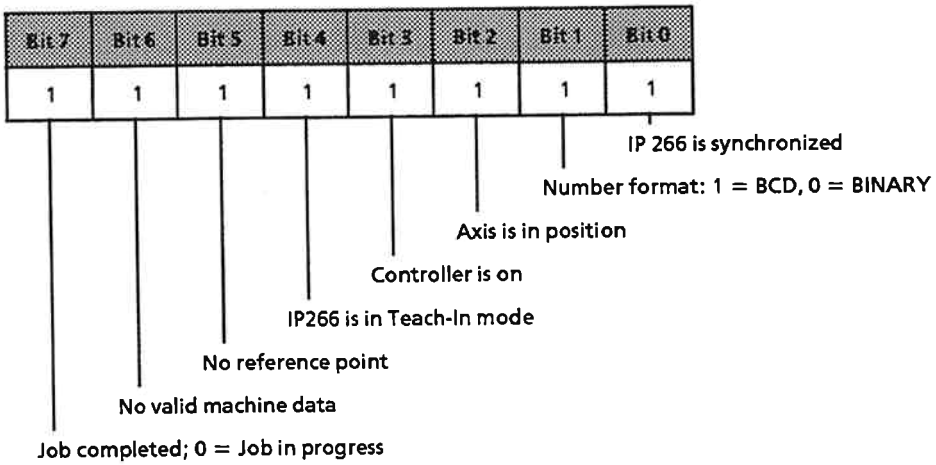
Value range of Mnn: nn is a two-digit number in the range 00 to 99. If no M function is programmed, the IP 266 forwards the three-digit number "255" to the COM program (PLC format KH: "FF"; format KF: "- 1").

Example:
The IP 266 returns the following in byte 1:

KF = +50

⇒ An M50 function has been written in the machining program.

7.2.3 Byte 2: Status Bits



Bit 0 = 1 The IP is synchronized. This bit is set to "1" if the IP 266 was correctly synchronized with mode 99.

= 0 This bit is set to "0" on every IP 266 runup (Ident run).

Bit 1: Specified number format
Binary or **BCD** has been entered in the machine data on the IP 266.

The IP 266 returns the relevant code in bit 1 so that you will be able to interpret the values for position specifications correctly.

= 1: BCD
= 0: Binary

Bit 2 = 1 The axis is in position. This bit is set when the actual position is within the standstill or zero-speed monitor's tolerance range (see Section 2.5.6).

This bit also goes from 0 to 1 when a dwell time has expired.

Bit 3 = 1 The controller is on. This bit is always set when the position controller is on.

= 0 This bit is set to "0" in modes 3 and 4.

Bit 4 = 1 The IP 266 is in Teach-In mode. This bit is set when you select mode 10 (Teach-In mode).

= 0 This bit is reset to "0" when the Teach-In mode is terminated by invoking mode 11.

Note:

When mode 10 is aborted because of an "error in the position control loop", the IP 266 enters mode 4. When mode 4 is terminated with the Stop command, the Teach-In mode must also be terminated by invoking mode 11.

Bit 5 = 1 No reference point has been set. Target positions may be specified or a machining program invoked only when a reference point has been set. An error is flagged if you attempt to execute an operation that requires a reference point.

= 0 The reference point is set.

Bit 6 = 1 Valid machine data is not available. You can start a mode only when the IP 266 has been correctly initialized, i. e. when valid machine data is available.

= 0 Valid machine data is available on the IP 266.

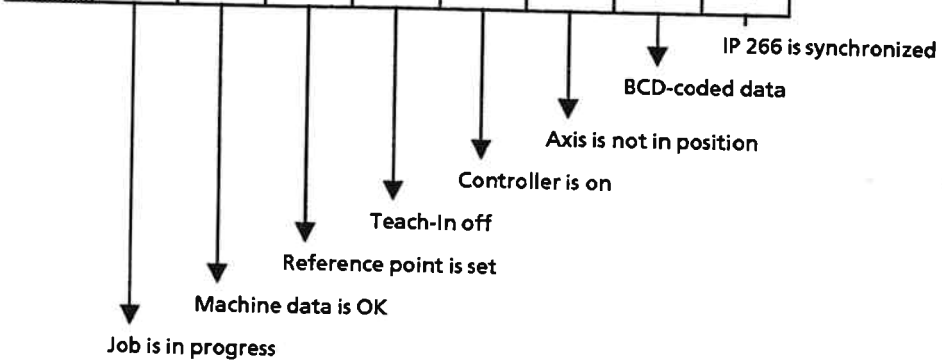
Bit 7 = 1 This bit is set when a job has executed.
In modes 8 and 9, it is set only when the relevant mode has terminated. It is not set after single machining operations.

= 0 The job is in progress.

Example 1:
The reference point is set:
The IP 266 services a job request in a controlled mode (e. g. mode 6). The status data is returned in BCD format. All input data is valid.

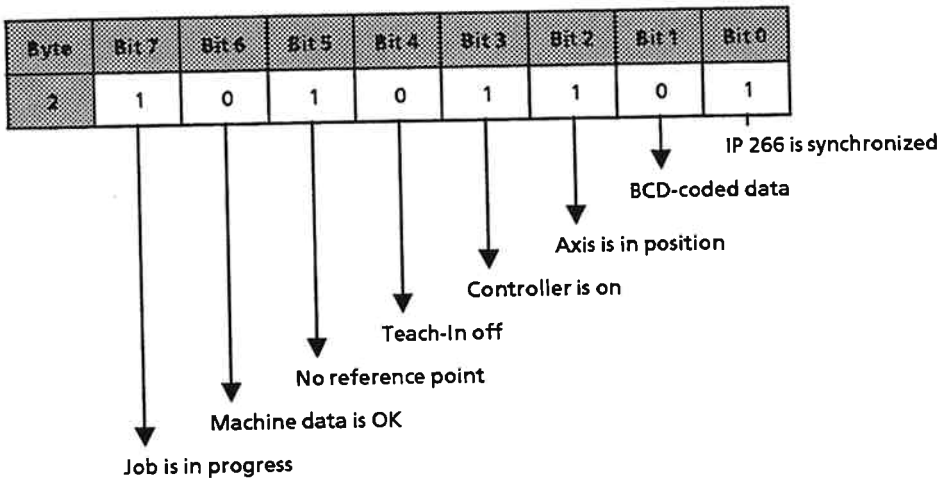
The IP 266 returns the following in byte 2:

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
2	0	0	0	0	1	0	1	1



Example 2:
The IP 266 receives a request to position the axis in a controlled mode (mode 1, 2 or 7). All status data is returned in binary. The machine data is correct. There is no reference point.

The IP 266 returns the following in byte 2:



7.2.4 Byte 3: Error Flags

IP 266 errors are flagged in bits 0 to 7 of byte 3. The error code is right-justified and in binary. Use KH (hexadecimal constant) format to read the error code. You will find a list of error messages in Section 10.

The error codes forwarded to the PLC are identical to those output by COM 266.

7.2.5 Bytes 4 to 7: Input Values for the Monitoring Functions

In each firmware cycle, the IP 266 returns a monitoring mode-dependent value. If you entered a monitoring function in the output frame for the IP 266, the IP 266 returns a current value in bytes 4 to 7 at regular intervals. These values can be read out in either KF or KH format.

	Binary (KF format)	BCD (KH format)
Integer positions	Byte 4 Byte 5	Byte 4 Byte 5 Byte 6 (bits 4 to 7)
Decimal positions	Byte 6 Byte 7	Byte 6 (bits 0 to 3) Byte 7

Example:
The drive is positioned under closed-loop control in "JOG 2" mode (mode 2). Monitoring function mode 72 was also selected in the output frame.

⇒ The IP 266 returns the current following error in bytes 4 to 7,
e. g. + 5.310 mm

Position specification	Byte 4	Byte 5	Byte 6	Byte 7
Binary in KF format	+5 = sign and integer digits		310 = decimal digits	
BCD in KH format	0000 = sign and 3 integer digits		5310 = least-significant integer position and 3 decimal digits	

7.2.6 Operating the IP 266 in the ET 200

To operate the IP 266 in the ET 200, special rules apply. These rules are explained in the following.

Since the S5-100U PLC and the ET 200 have different cycle times, you must ensure that every "Job completed" bit can be detected and evaluated.

This must be guaranteed at the programming stage.

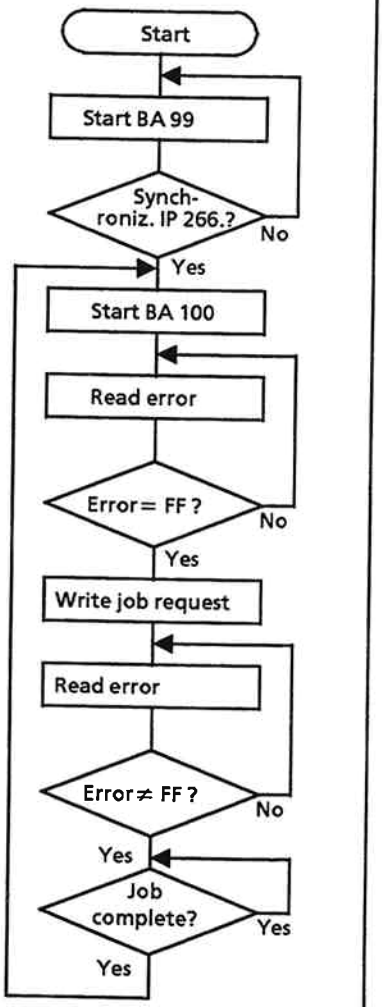
For this reason, version 2 of the IP 266, MLFB 6ES5 266-8MA11, contains one further mode which can be used to ensure clear detection of the "Job completed" bits.

Mode 100

- sets the "FF" error signal. All subsequent decisions of the STEP 5 program are linked to this error message.
- must be invoked before all modes which terminate the current job and set the "Job completed" bit autonomously - without external abort or STOP command .
- aborts jobs flagged with "Job in progress".

In jog mode, direct change from FORW → REV or REV → FORW is only possible over the additional STOP command.

The following flowchart outlines the principle of operation with the ET 200.



After the CPU STOP - RUN changeover, the IP 266 must be synchronized with mode 99. The synchronization is flagged in byte 2/bit 0 with a "1".

Mode 100 sets error message "FF". If the message is read out of byte 3/bit 0 to 7, the IP 266 is ready to accept a new job request.

A new mode can be started when error message "FF" is received.

Reminder:
Enabling a mode deletes any outstanding error message (except in the case of information modes). As soon as the error message has been deleted, the job is accepted.

The "Job completed" bit is scanned in the subsequent wait loop.
The bit set enables the next job.

Information modes must **not** be invoked according to this method since they do not reset outstanding error messages when they are invoked.

If "IP STOP if PLC STOP" is entered with "YES" in the machine data, the IP 266 goes to STOP with the message "PLC failure".

However, operation can be continued over COM 266. This means that "Startup" of the IP 266 is also possible when the PLC is still at STOP.

Address codes for I/O modules

The address code for input/output modules (095) given in the "ET 200 Distributed I/O System" Manual must be replaced by the new value 223.

8 Start-Up

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8 Start-Up

8.1 Configuring the System

Before putting the IP 266 into operation, you must check to make sure that you are using the right interface module and that the peripheral elements have been assigned the correct parameters.

These peripheral elements include:
- the emergency limit switches
- the power section on the IP 266's analog output
- the hardware limit switches
- the drive system mechanics
- the incremental position encoder
- the programmer.

8.1.1 IP 266 Limit Switches

In order to limit the positioning range, you must fit limit switches which ensure that the drive will be moved only within its mechanical limitations.

> **Warning**
>
> The limit switches must be connected and tested before powering up the IP 266 and the power section.

As regards the IP 266, you must differentiate between software limit switches, hardware limit switches and emergency limit switches.

- Software limit switches
  You define the locations of the software limit switches in the machine data. These switches are activated when a reference point is set.
- Hardware limit switches
  Hardware limit switches are switches which are connected to the IP 266 via connecting leads. They are connected to the terminals on the terminal block, and are used to limit the path of travel.

▸ **Check the following carefully:**
- The hardware start limit switch defines the start of the traversing range, and must be connected to PIN 3 on the terminal block.
- The hardware end limit switch defines the end of the traversing range, and must be connected to PIN 5 on the terminal block.

> **Note:**
>
> You must observe the minimum distances when installing the limit switches, i. e. there must be a sufficient distance for deceleration.

The hardware limit switches are properly connected. ok ◯

- Emergency limit switches
  The emergency limit switches must be directly connected to the power section. When a hardware limit switch fails, the emergency limit switch must ensure a reliable power section shutdown.

▸ **Check the following:**
The connecting leads for the two emergency limit switches must be run directly to the power section.

> **Caution**
>
> Connecting the emergency limit switches to the IP 266 is not allowed.

The emergency limit switches are properly connected. ok ◯

8.1.2 The Power Section on the IP 266's Analog Output

The power section must be connected to the IP 266's analog output.

▸ **Check the connection between the IP 266 and the power section**
When you calibrate the power section, make sure that there is sufficient power reserve. The drive must never be operated at the current limit, as the motor speed could not follow the setpoint speed.

8.1.3 Drive System Mechanics

All mechanical elements located between the motor and the part of the drive to be positioned are part of the drive system mechanics.
There may be play (backlash) in the drive system.

> **Caution**
>
> Backlash can be compensated for only when it is outside the position control loop. Backlash within the position control loop results in oscillations in the control response.

To prevent backlash in the position control loop, the incremental position encoder should be connected directly to the motor shaft.

▸ Check your drive system for backlash.
If you detect backlash outside the position control loop, measure it exactly.
⇒ The backlash is ☐ mm/inches/degrees

8.1.4 The Incremental Position Encoder

Control precision depends on the location of the encoder in the drive system. A sequence of movements can be easily verified when the encoder is mounted directly on the motor axis.

▸ **Check to make sure that the encoder is correctly installed.**
You must use an encoder which supplies two pulse trains displaced by 90 deg. with respect to each other and a zero mark signal.
You may use a 5 V or a 24 V encoder.
In addition to all required signals, the 5 V version must also supply the inverted signal for each signal.

Which encoder version are you using? ☐ V

If you are using a 5 V encoder, check the following:
Does the encoder supply the inverted signals?

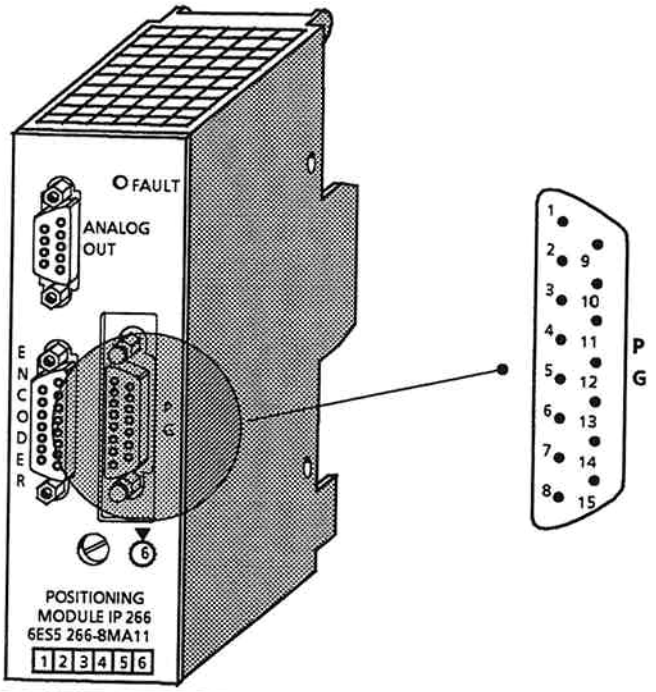
You must select an encoder resolution that enables evaluation of a sufficient number of pulses per interval even at low speeds. The minimum resolution should be greater than the positioning accuracy.

The maximum operating frequency of encoder and module must not be exceeded at V_{max}. The maximum operating frequencies for 5 V and 24 V encoders are as follows:

- For symmetrical 5 V encoders: 500 kHz
- For asymmetrical 24 V encoders: 100 kHz (for a max. cable length of 25 m)
  24 V encoders: 25 kHz (for a max. cable length of 100 m)

8.1.5 Programmer

The module is equipped with two 15-pin D subminiature interfaces. The programmer must be connected to the one at the right.



Pin	Description
1	Shield
2	RxD_N
3	-
4	-
5	-
6	TxD_P
7	TxD_N
8	Shield
9	RxD_P
10 to 15	-

Figure 8-1. Location of the Programmer Interface and Connector Pin Assignments

Caution

The programmer interface and the encoder interface both have 15 pins, and it is possible to confuse the two. Remember that the programmer interface is the one on the right.
If you confuse the two, the module executes a Reset.

8.1.6 Checking the Wiring

- Check all cabling ok○

  - Make sure that the control cable and the power cable are sufficiently far apart and without kinks. ok○

  - Make sure that the cables to and from the controller are shielded over their entire length, and that the cable shields are grounded at both ends. ok○

One important point is the laying of the ground wires, as insufficient cross-sections, ground loops or failure to connect the ground may result in malfunctions. Locating and eliminating such problems can be costly and time-consuming.

- Make sure that the ground wires have sufficient cross-sectional area and are properly laid and connected. ok○

- If you are using a 5 V encoder, check to make sure that the inverse signal leads are shielded. ok○

- Make sure that the leads for the n_{set} and **M** signals are shielded and twisted. ok○

- Check the following cables for short-circuits and wirebreaks and make sure that the pin assignments are as described in the section dealing with the hardware (Section 2):

  - Encoder cable (ENCODER) ok○

  - Setpoint cable (ANALOG OUT) ok○

  - Digital cable ok○

  - **FUM signal wired?** ok○

  - 24 V supply ok○

  - After making sure that all components are off circuit, attach the cables and screw them down. ok○

8.2 Computing the Machine Data

In this section, you will learn to compute the machine data with which you must initialize the IP 266. The machine data is based on the capabilities and mechanics of the drive.
In order to compute the machine data, you need information on the hardware.
Please take this information from the data sheets describing the drive and/or from the commissioning report.

Table 8-1. Data for Initializing the IP 266 Hardware and the Peripheral Elements

The following data is required	Abbreviation	Unit
• Motor/axis ratio	$\ddot{u}$	[1]
• Motor speed at 10 V	n_{10V}	[1/min]
• Travel per encoder revolution	x_G	[mm]
• Pulses per encoder revolution	l_G	[1]
• Hardware start limit switch	H_A	[mm]
• Hardware end limit switch	H_E	[mm]
• Time needed to decelerate from $v_{max.}$ to zero speed	t	[s]

The following values are computed on the basis of this data:

Table 8-2. Formulas for Computing the Machine Data

Maximum velocity (speed) $V_{max}\,[^{mm}/_{min}] = x_g \cdot n_{10V} \cdot \ddot{u}$	The factor $\ddot{u}$ must be taken into account only when it is not part of x_g.
Maximum deceleration rate b_{max} $b_{max}\,[^{mm}/_{s^2}] = \frac{V_{max}}{t} \quad \frac{[^{mm}/_{60s}]}{[s]}$ $b_{max}\,[^{mm}/_{s^2}] = \frac{V_{max}}{t \cdot 60} \quad \left[\frac{mm}{s^2}\right]$	Take the time from the commissioning report for the power section you are using.
Maximum following error Δs $\Delta s\,[mm] = \frac{V_{max}}{Kv} \quad \frac{[^{mm}/_{60s}]}{[^1/_s]}$ $\Delta s\,[mm] = \frac{V_{max}}{Kv \cdot 60}$	
The following data is computed from the results of these calculations	
Kv (gain) factor Kv $[^1/_s]$	The gain factor depends on the design, dynamics and disturbance variables (load variations) affecting your drive. An optimum gain factor cannot be ascertained until the system is actually put into operation. A very low value (1 to 2 1/s) should be selected for start-up in order to avoid damage.

Computing a set of machine data:

Machine data item	Limits	Example
Module	0 to 99	11
Measuring system	mm, in, deg.	mm
Axis type	Linear, rotary	Linear
The following applies for all deceleration and acceleration rates: $\lvert a\rvert \le \lvert b_{max}\rvert$ $\lvert b\rvert \le \lvert b_{max}\rvert$ The absolute acceleration and/or deceleration rates must be less than the absolute maximum deceleration rate b_{max}.		
Maximum deceleration	10 to 9999 mm/s^2	1000 mm/s^2
Acceleration fwd.	10 to 9999 mm/s^2	500 mm/s^2
Deceleration fwd.	10 to 9999 mm/s^2	500 mm/s^2
Acceleration rev.	10 to 9999 mm/s^2	500 mm/s^2
Deceleration rev.	10 to 9999 mm/s^2	500 mm/s^2
Encoder type	5 V, 24 V	5 V
IP-STOP if CPU-STOP	yes, no	no
Gain factor	0.1 to 99.9 $1/s$	16.6 $1/s$
Backlash compensation	0.000 to 64.999 mm	0.000 mm
Zero-speed monitor	0.001 to 64.999 mm	2.000 mm
Max. following error	0.001 to 99.999 mm	15.000 mm
Following error monitoring	on, off	on
The following condition applies for the switching elements - software start limit switch X_{SA} - software end limit switch X_{SE} - reference point coordinate REF: $X_{HA} < X_{SA} < X_{REF} < X_{SE} < X_{HE}$ X_{HA} is the hardware start limit switch, X_{HE} the hardware end limit switch.		
Reference point coordinate	± 32767.999 mm	0.000 mm
Software start limit switch	± 32767.999 mm	-400.000 mm
Software end limit switch	± 32767.999 mm	400.000 mm
Tool length offset	± 32767.999 mm	0.000 mm
For a rotary axis, the two fields for the software limit switches are replaced by the two fields start of traversing range and end of traversing range. The range limits are identical to those for a linear axis.		
Zero offset 1	± 32767.999 mm	10.000 mm
Zero offset 2	± 32767.999 mm	25.000 mm
Zero offset 3	± 32767.999 mm	30.000 mm
Zero offset 4	± 32767.999 mm	35.000 mm

Machine data item	Limits	Example
All speeds must be lower than V_{max}		
Maximum speed	1 to 65000 $^{mm}/_{min}$	15000 $^{mm}/_{min}$
Jog speed 1 fwd.	1 to 65000 $^{mm}/_{min}$	2000 $^{mm}/_{min}$
Jog speed 1 rev.	1 to 65000 $^{mm}/_{min}$	2000 $^{mm}/_{min}$
Jog speed 2 fwd.	1 to 65000 $^{mm}/_{min}$	4000 $^{mm}/_{min}$
Jog speed 2 rev.	1 to 65000 $^{mm}/_{min}$	4000 $^{mm}/_{min}$
Incremental speed	1 to 65000 $^{mm}/_{min}$	12000 $^{mm}/_{min}$
Reference point approach speed 1	1 to 65000 $^{mm}/_{min}$	1000 $^{mm}/_{min}$
Reference point approach speed 2	1 to 65000 $^{mm}/_{min}$	500 $^{mm}/_{min}$
Reference direction	fwd./rev.	fwd.
Pulses/revolution	1 to 65000 $^{pulses}/_{rev.}$	1000 $^{pulses}/_{rev.}$
Distance/revolution	0.001 to 400.000 mm	5.000 mm
PLC BCD-coded	yes, no	no
Polarity HW limit switch	pos/neg	neg

8.3 Initializing the IP 266

Before you can use the IP 266, you must first supply it with valid machine data.
You have two options for entering machine data:

- Defining machine data for a newly installed system
- Loading an existing record from a non-volatile storage medium

Entering machine data for a newly installed system
Before putting a new system into operation, you must define your machine data for that system. The information presented in Section 8.2 showed you how to compute the required data on the basis of the drive's technical specifications.

To enter your machine data, you need a programmer and the COM 266 software package.

Start COM 266 as described in Section 6 and proceed to the "FUNCTION SELECT" menu. All COM 266 basic functions are invoked from within this menu.
The input of machine data is described in detail in Section 6.4.1.

Loading an existing record from a non-volatile storage medium
Invoke the TRANSFER function in the "FUNCTION SELECT" menu (see Section 6.5) to load an existing set of machine data.

8.4 Executing the Start-Up Test

The drive must be within the permissible traversing range before the IP 266 can be tested together with the drive. This range is defined by the two hardware limit switches.

> **Caution**
>
> All limit switches must be correctly installed before executing the start-up test, i. e. both the hardware limit switches and the emergency limit switches must be connected. Remember that you can actuate the emergency off switch at any time!

It has been assumed that your power section has been matched to the drive.

The first step

- Power up the PLC

  No CPU program need be available at this point.
  If you entered "yes" for "IP-STOP if CPU-STOP" in the IP 266 machine data, the CPU must be at RUN.
  The CPU should not address the IP 266 during the first phase of the start-up procedure.

- Switch on the 24 V supply

  The power section is still off.

- Connect the programmer to the IP 266

- Start COM 266
  (ON-LINE)

Keep an eye on the monitor's error line when making your entries. If a problem occurs, it will be flagged on this line.

For testing, a set of machine data and a traversing program are stored on EEPROM. Since this data does not necessarily coincide with your hardware, you may find that errors will be reported. Change the machine data as indicated by the error messages. These messages, and the changes they indicate, will apply primarily to the encoder type, the polarity and the encoder resolution.

> **Caution**
>
> The IP 266 outputs the enable signal (FUM) directly when it detects data whose logic and signal level are correct. If a positioning operation was triggered, it will be started immediately!

- Correct the machine data as indicated by the error messages.

- Generate a traversing program for modes 8 and 9 and transfer it to the IP 266.

Testing the axis

- ▸ Select the COM 266 test mode.
- ▸ Start mode 4 (follow-up mode)
- ⇒ The following is displayed in the screen form's output fields:

Axis status: running	ok ◯
CLC: off	ok ◯

- ▸ Switch on the power section
- ⇒ The axis must remain at zero speed and its drift must be barely perceptible. If this is not the case, you must repeat the fine adjustment for 0 volts on the drive.
- ▸ Stop mode 4 and check the return data.

Axis status: finished	ok ◯
CLC: on	ok ◯

Testing the encoder's direction of rotation

> ⚠ **Caution**
>
> If the encoder rotates in the wrong direction, there is direct feedback from the position control loop (the CLC is on). As a result, the drive, instead of stopping, traverses at maximum speed. You must therefore make sure that the drive can be immediately stopped via external switches whenever necessary while performing this test. Should the drive begin to oscillate when it is at zero speed, you must reduce the gain (Kv) factor!

The IP 266 monitors the position control direction, aborting the current operation with an error message when an error occurs and starting mode 4.
When the IP detects the correct sense of rotation, it disables the monitor; the monitor remains disabled until mode 4 is once again started. When mode 4 is terminated, the position control direction is again monitored.

Please note:
A forward traversing movement always means a movement in the direction of the software end limit switch, whose coordinate position must be higher than that of the software start limit switch. The IP 266 generates a positive output voltage (setpoint speed). The incremental encoder must be connected to the IP in such a way that the resulting direction of rotation causes the IP's counter to function as an up counter. The IP's counter counts up when the A signal is detected before the B signal. The opposite is true in the event of a reverse traversing movement.

As regards the direction of rotation of the encoder and the motor, the conventions are the same for linear and rotary axes. A clockwise (or forward) traversing movement always means a positive output voltage (setpoint speed), a counter-clockwise (or reverse) traversing movement a negative output voltage. When the axis traverses in a clockwise direction, the IP's counter must count up. A forward movement moves the axis toward the end of the traversing range, which, in the case of a rotary axis, is the same as the start of the traversing range, but which must always be more positive than the latter.

- Select mode 3 (Controlled jog).
- Select a low speed (approx. 1-5 %) via "Override".
- Select the "Forward" function and observe the actual position; this value must increase.

If the actual position value decreases, switch off the power section immediately!

In this case, you must interchange encoder signals A-A\ and B-B\ (if you are using a 5 V encoder) or A* and B* (if you are using a 24 V encoder) and retest the direction of rotation. Forward travel must result in an increase in the actual position, reverse travel in a decrease.

Testing the hardware limit switches

- Initiate forward traversing in mode 3.
- Trip and hold the hardware end limit switch.
  The traversing movement must be aborted with the "HW end limit switch tripped" error message. There must be no further travel when a new "Mode 3 forward" command is issued.

  ok ◯
- Initiate reverse travel in mode 3.
- Release the hardware end limit switch during traversing.
- Trip the start limit switch.
  The traversing movement must be aborted with the error message "HW start limit switch tripped". There must be no further travel when a new "Mode 3 reverse" command is issued.

  ok ◯
- Start mode 3 "Forward" and release the hardware start limit switch during traversing. Traversing movements in both directions are now once again possible.

Refer to the following figure when you want to simulate tripping of a limit switch within the traversing range:

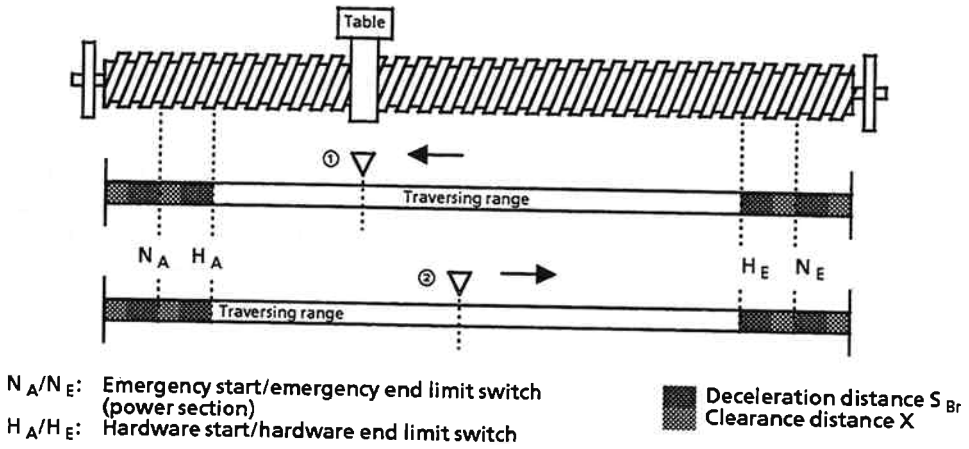


Figure 8-2. Linear Axis with Range Limit Switches (not to scale)

① Move the drive at a controlled jog toward the hardware start limit switch. During traversing, actuate the relevant limit switch briefly, then release it.
The drive decelerates at maximum deceleration speed.
Travel is now possible only in the direction of the hardware end limit switch.

② Move the drive at a controlled jog toward the hardware end limit switch. During traversing, actuate the relevant limit switch briefly, then release it.
The drive decelerates at maximum deceleration speed.
Bidirectional travel is now **impossible**.

Should this situation occur, you must hold the relevant hardware limit switch in one of the two directions before starting the "controlled jog".

Testing the following error

- ▸ Travel a considerable distance in mode 1 or 2 ("Jog 1" or" Jog 2"), observe the following error, and stop travel.
- ⇒ The result must be the buildup of a following error which, after some time, remains fairly constant and then goes back to zero following deceleration. At zero speed, the following error can vary by approximately ± 3 increments, depending on the drive calibration. If it varies by more than ± 3 increments, you must either increase the Kv factor or recalibrate the drive. The following error should assume approximately the following value during traversing:

$$\Delta s\,[mm] = \frac{v\,[mm/min]}{60 \cdot kv \cdot [1/s]}$$

Testing the maximum speed

- ▸ Move your drive in mode 3 with an override factor of 100%.
- ⇒ The computed speed is displayed in the test form. If this speed does not coincide with the speed specified in the machine data, you must check and correct your specifications.

Computing the reference point

- ▸ Select "Reference point approach" mode (mode 5).

- ▸ Initiate the "Start" function.
- ⇒ The drive must execute a traversing routine and return "Reference point set".

ok ◯

Possible errors:

1. The drive does not move although "Reference point set" is displayed.
   You have accidentally executed a "Set reference point".

2. The drive traverses, but does not reduce its speed at the reference point switch and does not find the reference point.
   The reference point switch is either defective or is an "NC" contact.

3. The drive reduces its speed at the reference point switch, but continues traversing until it reaches the limit switch. "Reference point deleted" is displayed on the monitor.
   The zero mark of the encoder is not used in the IP 266. You must test the reference point switch signal and the zero mark signal.

If the reference point exists, the software limit switches are also effective.

- ▸ Traverse in both directions in mode 1 or 2 and check to see whether the software limit switches are tripped before the hardware limit switches are reached.
  If necessary, you must shift the coordinates of the software limit switches so that the drive comes to a standstill before reaching the hardware limit switches.

Increment mode

Once the coordinate system has been established, you can approach absolute target positions.

- ▸ Enter various different target positions in modes 6 and 7 and check to see if the axis reaches these positions.

Executing automatic programs

- ▸ Write a short traversing program and transfer it to the module.

- ▸ Test this program in modes 8 and 9.

Teach-In

- Select mode 10 ("Teach-in on").
- Specify a program number.
- Start mode 10.

  ⇒ Return info: Teach-in: on ok ◯
- Approach various positions and store them with "Transfer".
- Start mode 11 ("Teach-in off").
- Execute the program you generated in "Teach-in" mode. Supplement the program in DIN or Text mode by adding
  dwells,
  loops,
  programmed stop,
  speed changes and the like.

Familiarize yourself with the following modes

- Zero offset absolute (mode 12) ok ◯
- Zero offset relative (mode 13) ok ◯
- Clear zero offset (mode 14) ok ◯
- Tool offset (mode 15) ok ◯
- Tool offset off (mode 16) ok ◯
- Acknowledge error (mode 17) ok ◯

▸ Generate an error such as "External STOP".
The error is flagged on the programmer ok ◯

▸ Start mode 17.
⇒ The error is acknowledged. ok ◯

- Drift compensation (mode 18) ok ◯
- Drift compensation off (mode 19) ok ◯

▸ ***Save the optimized machine data and traversing programs on floppy and transfer the contents of the floppy to the module's EEPROM.***

Controlling the IP 266 via the programmable controller

After testing the interplay between the IP 266 and your drive, you must test the positioning application in your STEP 5 program.
Refer to the following sections for help:

- Section 7, which describes communications between the PLC's CPU and the IP 266
- Section 9, which provides two examples for using the input and output messages.

9 STEP 5 Programming

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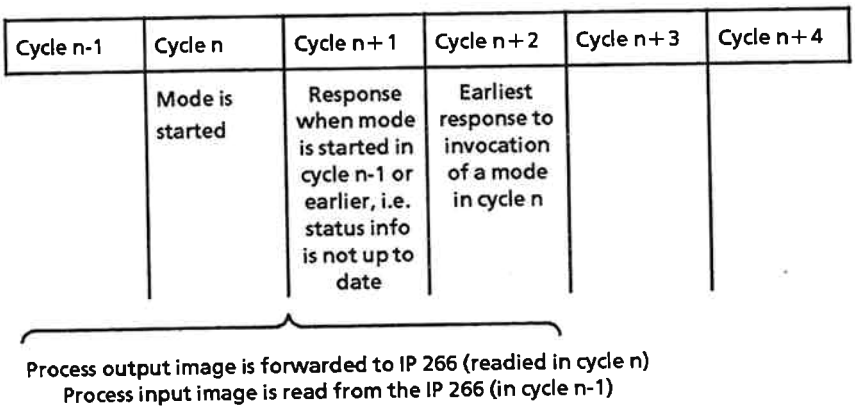
9 STEP 5 Programming

9.1 What to Observe when Programming

9.1.1 General Information on Program Structure

When programming the IP 266, you must observe a number of special features and exceptions. These are discussed in detail below.

Response to starting a mode
When you start a mode, you can expect the latest status info at the earliest two cycles later. If you are using a high-speed CPU in conjunction with a short OB 1 cycle time, you may not receive this information until the third or fourth cycle.



A special programming technique should be used to prevent repeated reading of "out of date" information.
Two optional techniques are discussed below:

- A blank cycle can be programmed in each second OB 1 cycle to ensure that the status info will be read no earlier than cycle n+2. However, this alone does not ensure that the current status info will be read.
- A preferable technique would be to evaluate the signal edge of the "Job terminated/in progress" bit.

9.1.2 Edge Evaluation and Modes

The preferable technique to ensure a readout of the latest status info is edge evaluation.
Sequence:

1. A job is started in cycle n. The status info shows "Job terminated".
2. The status info still shows "Job terminated" in cycle n+1 because the job had not yet been started when the process input image was read.

> **Note:**
>
> If this status bit were the only criterion for starting a new job, it would be possible to start another job at this point although the first is still in progress. The first job would thus be aborted and error F82 ("Inadmissible job") flagged.

The IP 266 reports "Job in progress" in cycle n+2 at the earliest.
It would therefore be preferable to use an edge flag to make sure that this problem cannot occur. No job can be started unless this flag is set, and it is set only when the IP 266 returns "Job in progress".

Application in example 2 (see Section 9.5):
When a job is started, flag 3.0 is reset. As long as this flag is not set, no job can be started. The flag is not set and a further job initiated until the IP 266 reports "Job in progress".
A new job can be started when the IP 266 changes the status bit from "Job in progress" to "Job terminated".

9.1.3 Programming the TOGGLE Bit

A change in the value of the TOGGLE bit informs the IP 266 that a new job request is waiting to be serviced. The IP 266 then interprets and executes this request.

Job n-1	Job n	Job n+1	Job n+2	Job n+3	Job n+4
To the IP 266 with TOGGLE = "1"	To the IP 266 with TOGGLE = "0"	To the IP 266 with TOGGLE = "0"	To the IP 266 with TOGGLE = "1"	To the IP 266 with TOGGLE = "1"	
⇩	⇩	⇩	⇩	⇩	
Job request is serviced	Job request is serviced	Job request is not serviced	Job request is serviced	Job request is not serviced	

In sample program 1, the TOGGLE bit is programmed in FB 25.

9.1.4 Error Analysis

Errors should be analyzed to enable the STEP 5 program to respond quickly to an event.
It is recommended that errors be analyzed in every cycle. When doing so, however, you should also keep track of the "Job terminated" bit so that you will not respond to "old" data.

9.1.5 Automatic Synchronization in OB 1

Mode 99 is the first mode the IP 266 will accept. Only then can one of the modes 1 to 73 be started. Mode 99 should therefore be invoked automatically in OB 1. The TOGGLE bit must always be set to "1" for this mode.

Note:

No status info is returned for mode 99. If this mode executes without error, bit 0 is set in byte 2 of the input message (PII).

9.2 Switches, Indicators and Flags in the Sample Programs

Maintained-contact/momentary-contact switches
All control elements for the program are interfaced over IB 3 and IB 4. Some inputs require only momentary-contact switches, while others require maintained-contact switches. Inputs I 3.0 to I 4.7 are listed in the table below.

Input	Function	Momentary-contact switch	Maintained-contact switch	Function
I 3.0	External start enable (IP pin 7)	•		NC contact
I 3.1	START		•	NO contact
I 3.2	STOP		•	NO contact
I 3.3	FORWARD		•	NO contact
I 3.4	REVERSE		•	NO contact
I 3.5	TRANSFER		•	NO contact
I 3.6	Override 100 % / 50 %	•		
I 3.7				
I 4.0	Selector switch for mode 5	•		NO contact
I 4.1	Selector switch for mode 2	•		NO contact
I 4.2	Selector switch for mode 6	•		NO contact
I 4.3	Selector switch for mode 8	•		NO contact
I 4.4	Selector switch for mode 9	•		NO contact
I 4.5	Absolute target specification +360.800 mm / -360.600 mm	•		
I 4.6				
I 4.7	Continuous operation for mode 7 (brief example in Section 9.5)	•		NO contact

Indicator elements/outputs

Output	Lights when/is on when	Call in
Q 2.0	No external start enable signal (IP pin 7)	FB 26
Q 2.1	IP not initialized/synchronized	OB 1
Q 2.2	No reference point	FB 26
Q 2.3	IP in follow-up mode	FB 26
Q 2.4	Axis not in position	FB 26
Q 2.6	"Lower drill"	FB 20
Q 2.7	"Raise drill"	FB 20
QB 5	Error code, hexadecimal (KH)	FB 20

Flags, auxiliary flags and edge flags

Flag	Function	Remarks
F 3.0	Edge flag (in example 2, Section 9.5)	This flag prevents a second job from being started until "Job in progress" has been returned (see Section 9.5).
F 4.0	Auxiliary flag for START	These flags prevent repeated forwarding of the same job requests to the IP when a command remains in force over more than one OB 1 cycle (see FB 20).
F 4.1	Edge flag for START	
F 4.2	Auxiliary flag for STOP	
F 4.3	Edge flag for STOP	
F 4.4	Auxiliary flag for FORWARD/REVERSE	
F 4.5	Edge flag for FORWARD/REVERSE	
F 4.6	Auxiliary flag for TRANSFER	
F 4.7	Edge flag for TRANSFER	

Flag	Function	Remarks
F 5.0	Auxiliary initialization flag	
F 6.0	START	FB 6 is transferred to byte 1 of the output message (QB 65 in the example). Before FB 6 is transferred to QB 65, the TOGGLE bit must be programmed in F 6.7.
F 6.1	STOP	
F 6.2	FORWARD	
F 6.3	REVERSE	
F 6.4	TRANSFER	
F 6.5		
F 6.6		
F 6.7		

9.3 Description of Sample Program 1

A workpiece is to be machined on an assembly line comprising several assembly bays. The following steps are to be carried out at four positions within the positioning range of the linear axis:

Position 0: Position 0 is the home position of the worktable in the linear axis's traversing range. It is at this position that a workpiece is to be placed on the table for machining and at which the workpiece is to be placed back on the table after machining.

Positions 1 to 3: Holes are to be drilled in the workpiece at these three positions. When the hole has been drilled at the last of these three positions, the drive is to return to position 0. The procedure can be restarted when the workpiece has been removed from the table.

A traversing program is used to approach positions 0 to 3. External activities in the STEP 5 program are initiated via M functions. Figure 9-1 shows an installation suitable for this example.

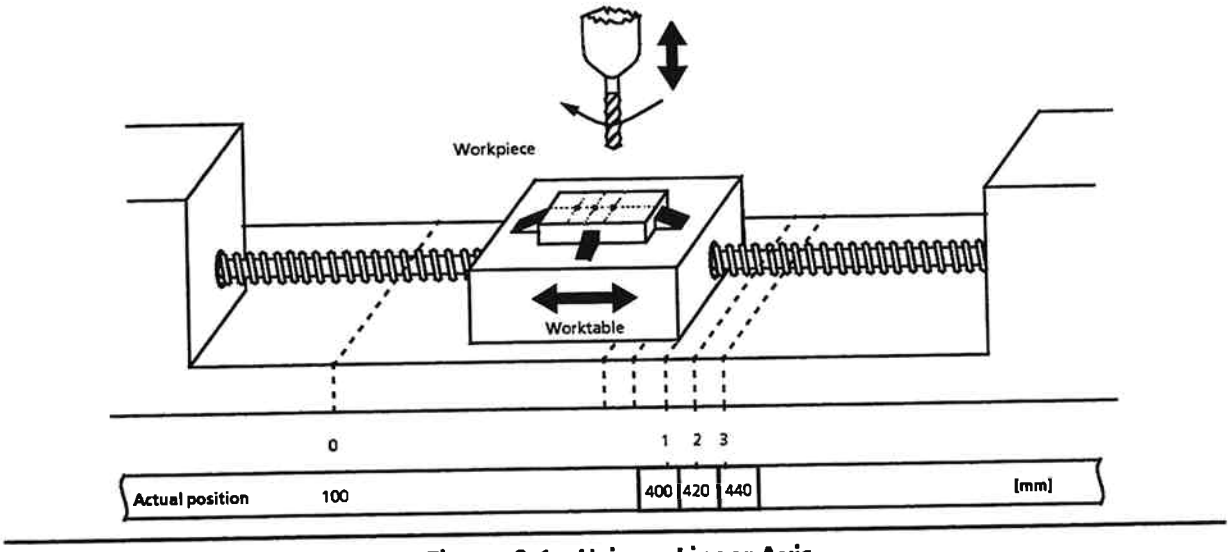
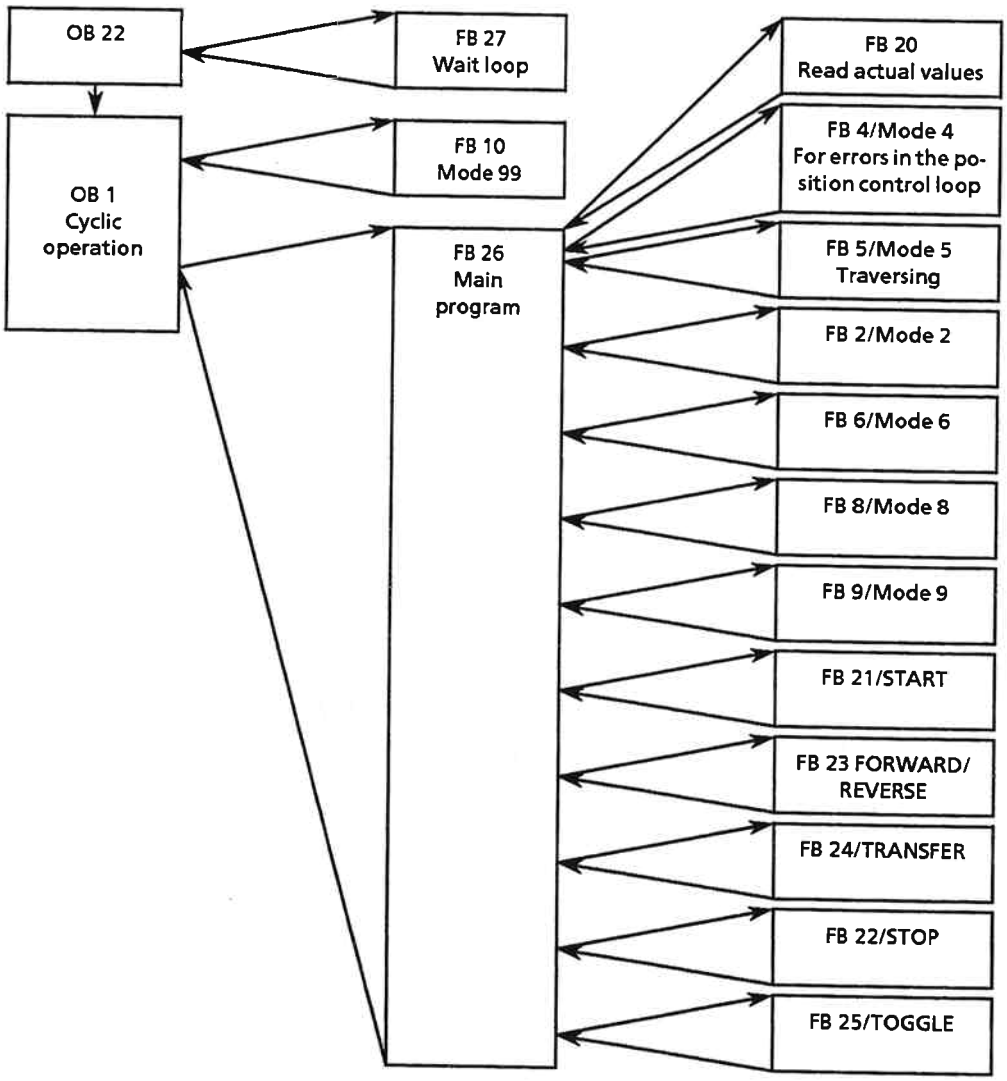


Figure 9-1. Using a Linear Axis

9.4 Sample Program 1: Overall Structure

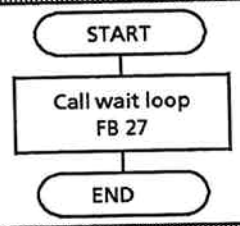
For better readability, many subfunctions have been programmed in separate FBs. The diagram below illustrates the overall structure:



9.4.1 Cold S5-100U Restart

Before you can work with the IP 266 following a cold S5-100U restart, you must wait for completion of the module's runup phase. You must program the waiting time in OB 22, which executes after every "Power OFF/Power ON". The programmed waiting time must be at least 3 seconds.

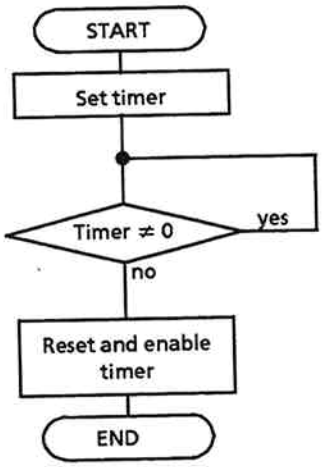
OB 22



Call the delay time FB.

```
      JU    FB    27
NAME  DELAY
      BE
```

FB 27 NAME: DELAY



Force RLO = 1 and load timer with 3 s

```
      JC    =M1
M1    L     KT 300.0
      SD    T     0
```

Time-out after 3 s

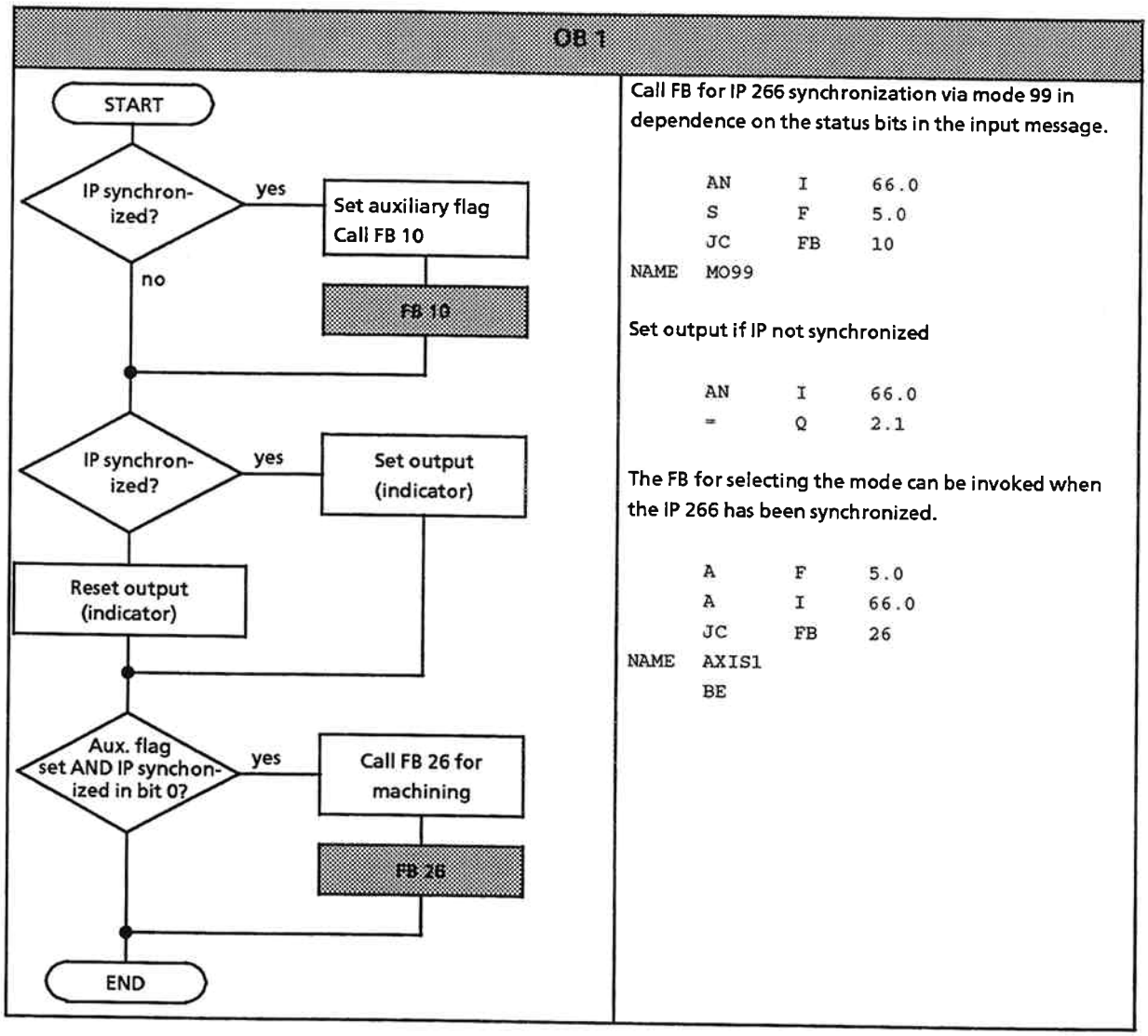
```
SCHL  AN    T     0
      JC    =SCHL
```

Reset timer and enable with RLO = 0

```
      A     T     0
      R     T     0
      A     T     0
      L     KT    001.0
      SD    T     0
      BE
```

9.4.2 Cyclic Operation with OB 1

At the beginning of each OB 1 cycle, a check must be made to see whether the IP 266 has been initialized. This check consists of scanning bit 0 in byte 2 of the input message (PII).
If the IP 266 has not been synchronized, mode 99 must be invoked in FB 10.
If the IP has been synchronized, FB 26 is invoked. All further functions in the sample program are started from FB 26.

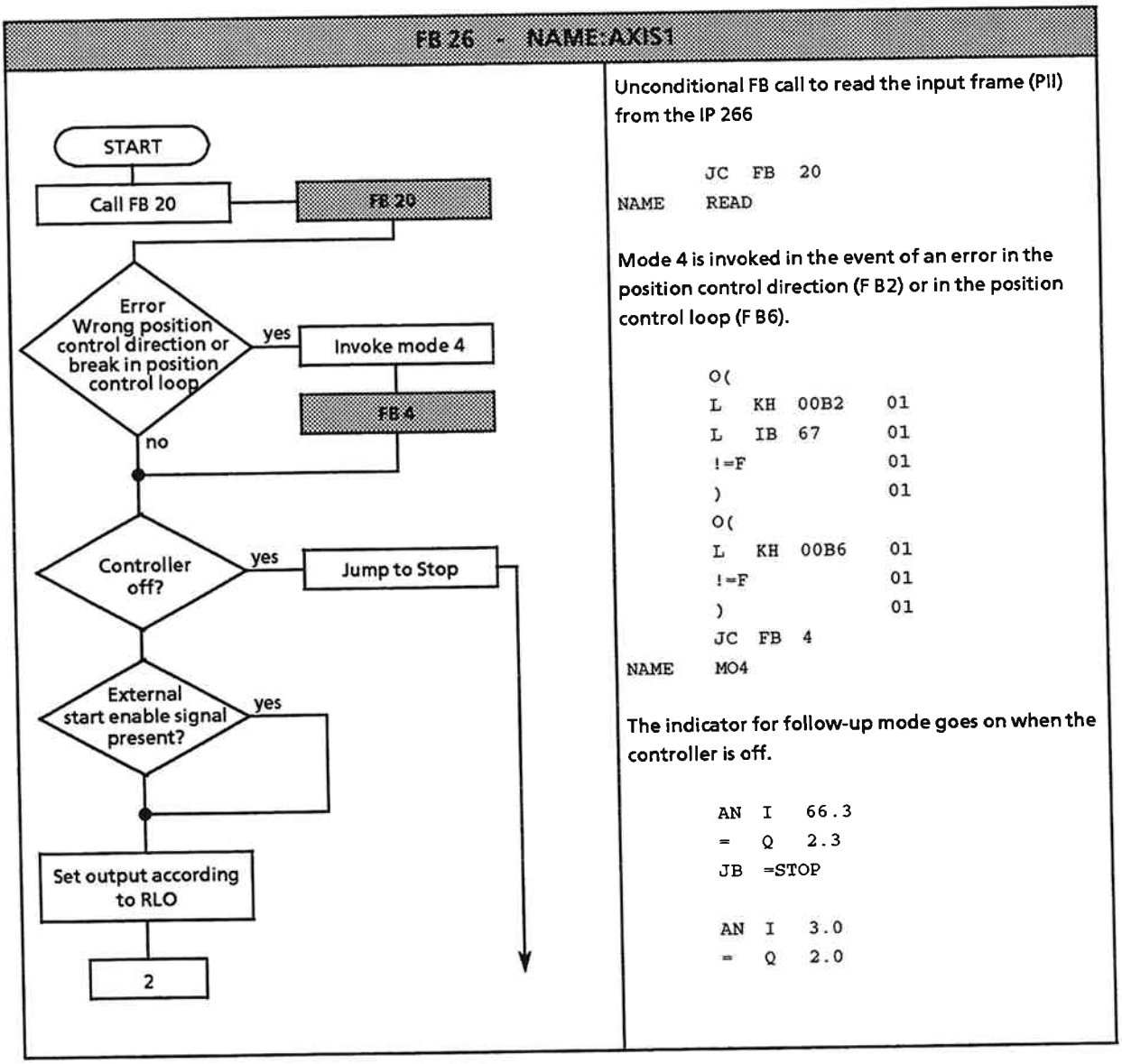


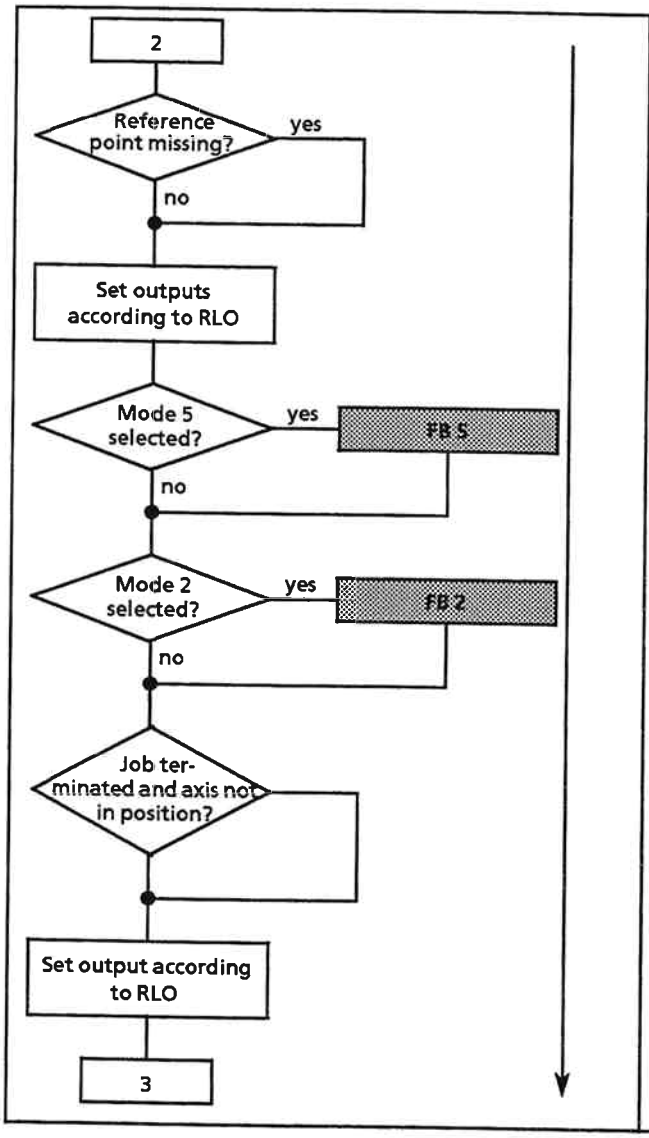
9.4.3 FB 26: Control FB for the IP 266

The following steps are executed in succession in this FB:

- Read input message (PII)
- Error analysis
- Scan external signals
- Check reference point and set if required
- Select mode
- Select function
- Program TOGGLE bit

The relevant calls must be made in this FB to invoke additional modes or change existing modes. The sample program could also be upgraded by programming mode interlocks. One complete FB 26 pass is equivalent to one OB 1 cycle.





Set output to indicate that there is no reference point

```
        A   I   66.5
        =   Q   2.2
```

Invoke mode for approaching/setting reference point when the relevant input is set.

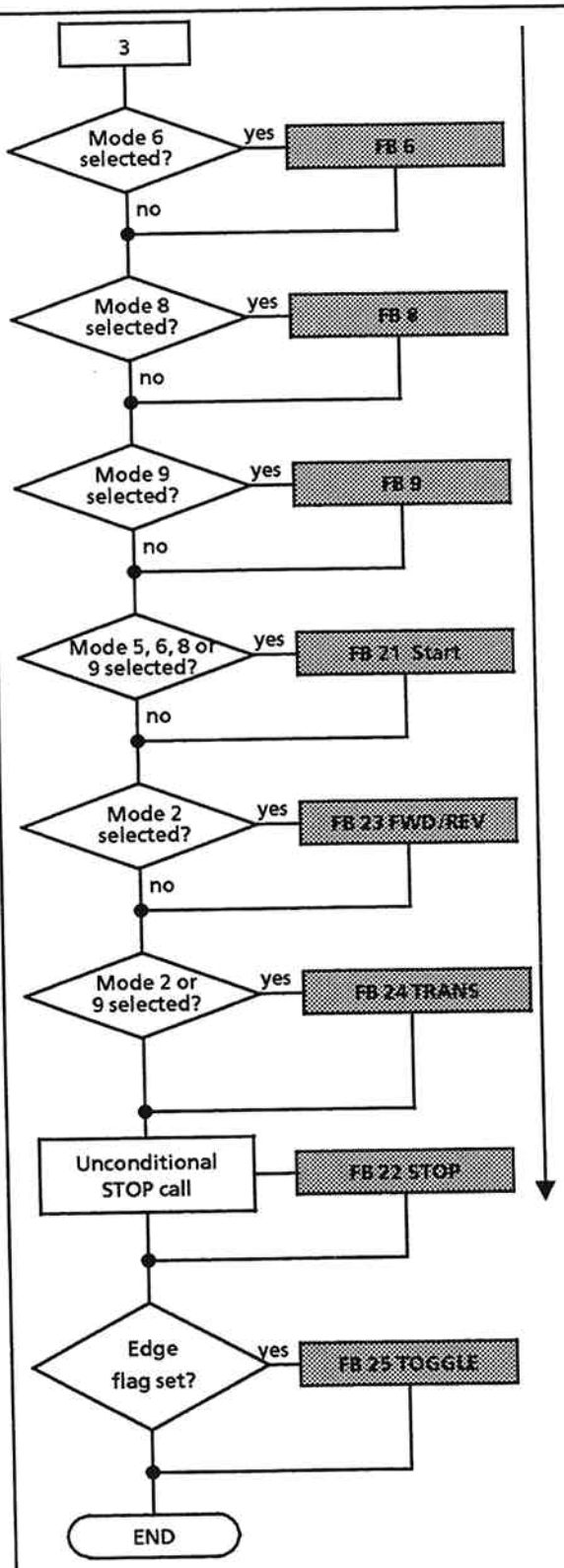
```
        A   I   4.0
        JC  FB  5
NAME    MO5
```

Invoke "Jog 2" mode when relevant input is set.

```
        A   I   4.1
        JC  FB  2
NAME    MO2
```

Set indicator for "Job terminated" AND "Axis not in position"

```
        A   I   66.7
        AN  I   66.2
        =   Q    2.4
```



Invoke mode 6, 8 or 9 when the associated input is set.

```
        A   I   4.2          MODE 6
        JC  FB  6
NAME    MO6
        A   I   4.3          MODE 8
        JC  FB  8
NAME    MO8
        A   I   4.4          MODE 9
        JC  FB  9
NAME    MO9
```

"START" in mode 5, 6, 8 or 9

```
        O   I   4.0          MODE 5
        O   I   4.2          MODE 6
        O   I   4.3          MODE 8
        O   I   4.4          MODE 9
        JC  FB  21
NAME    START
```

"FORWARD/REVERSE" in mode 2

```
        A   I   4.1          MODE 2
        JC  FB  23
NAME    FWDREV
```

"TRANSFER" in modes 2 and 9

```
        O   I   4.4
        O   I   4.1
        JC  FB  24
NAME    TRANS
```

Unconditional STOP call

```
STOP    JU  FB  22
NAME    STOP
```

Call the TOGGLE FB if edge flag for START, STOP, FWD/REV or TRANSFER was set.

```
        O   F   4.1     START
        O   F   4.3     STOP
        O   F   4.5     FWD/REV
        O   F   4.7     TRANSFER
        JC  FB  25
NAME    TOGGLE
        BE
```

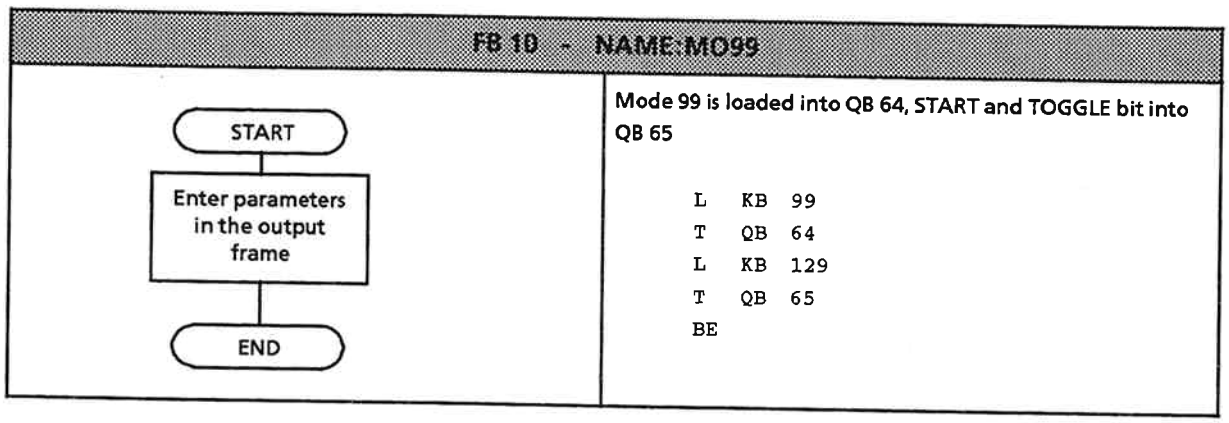
9.4.4 Selecting Modes via IB 4

All modes are selected in FB 26. In almost all cases, the number of the FB is identical to the mode number.

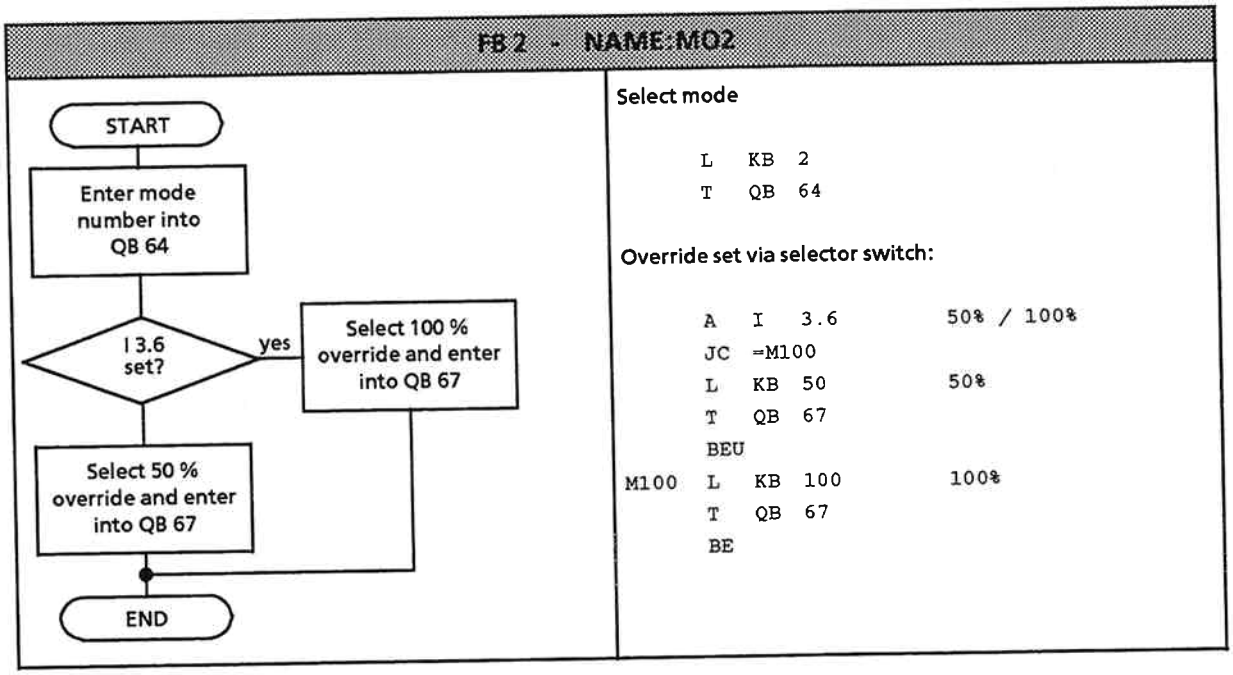
- FB 2 is for "Jog 2" mode
- FB 5 is for approach/set reference point mode
- FBs 6, 8 and 9 are for modes 6, 8 and 9
- The only exception is mode 99. Since not all CPUs allow FB numbers as high as 99, the FB number for this mode is 10. This mode is also the only mode that is directly invoked in OB 1.

All FBs for selecting a mode have the same structure. First, the number of the mode, in binary, is entered in output byte 64 (output byte 64 is byte 0 of the output frame; see Section 7.1). For some modes, the mode parameters are also preset in dependence on specific conditions, and entered in the relevant bytes.

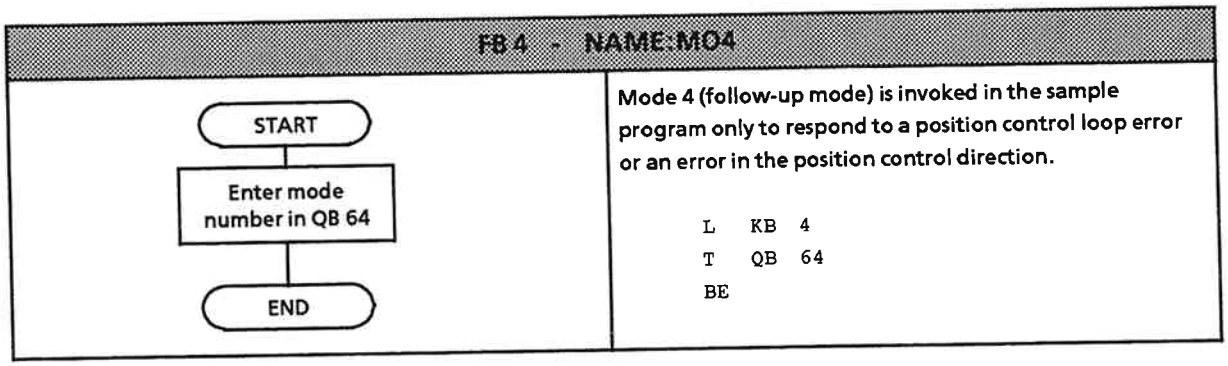
FB 10: Synchronize IP 266
FB 10 is always invoked automatically in OB 1 when bit 0 in byte 2 of the input frame is "0" (IB 66). If the IP has not been synchronized, mode 99 must be started with the TOGGLE bit = "1" and the START function.



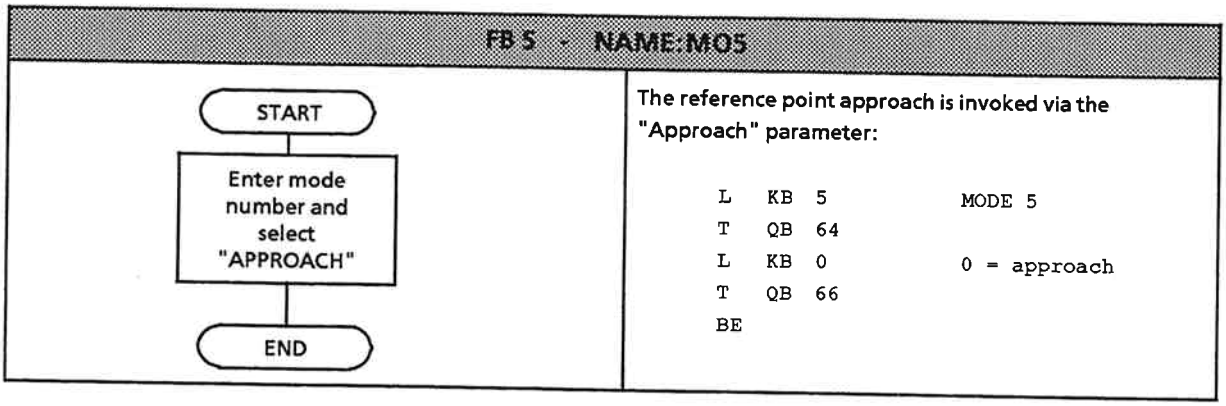
FB 2: Jog 2 with override specification
When the mode number has been entered into QB 64, input 3.6 is scanned. Select an override of 50 % or 100 %, depending on the selector switch setting. This value is entered in QB 67.



FB 4: Follow-up mode
The only entry made in this FB is the mode number. In the sample program, this mode cannot be selected via switches. It is invoked only to respond to error messages.



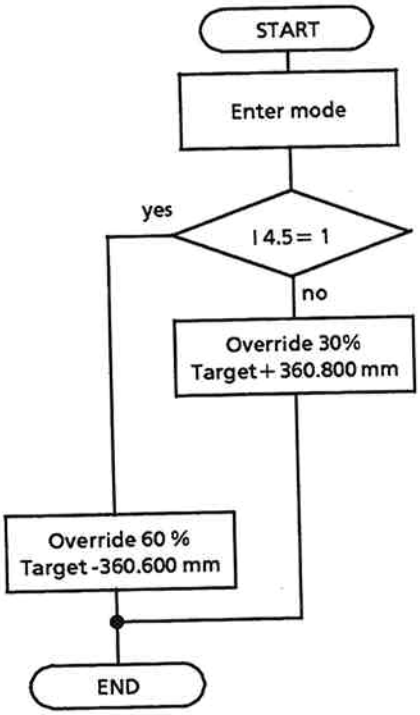
FB 5: Approach/Set reference point
When this operating mode has been selected, a "0" in QB 66 sets the "APPROACH" submode.



FB 6: Increment mode absolute
In addition to the mode number, this mode requires specification of an override factor and an absolute target position.
Simple parameters were chosen for the sample program.
Select the parameters as follows via input I 4.5:

I 4.5 = 0 positive direction	I 4.5 = 1 negative direction
Enter override factor 30 % in QB 67 and target position 360.800 mm in QW 68 and QW 70.	Enter override factor 60 % in QB 67 and target position 360.600 mm in QW 68 and QW 70.
If the positioning specifications are in binary, • QW 68 contains the integer digits and • QW 70 the decimal digits of the value	

FB 6 - NAME:MO6



Selecting mode 6

```
L   KB  6
T   QB  64
```

Determining the direction in dependence on the switch at input 4.5

```
A   I   4.5
JC  =MINU
```

Loading an override factor of 30% and the integer and decimal digits of the value for the positive direction of travel:

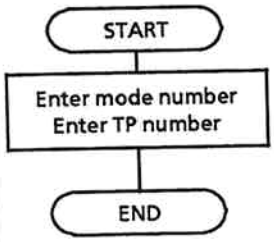
```
L   KB  30     OVERRIDE 30%
T   QB  67
L   KF  +360
T   QW  68     INTEGER DIGITS
L   KF  +800
T   QW  70     DECIMAL DIGITS
BEU
```

Loading an override factor of 60% and the integer and decimal digits of the value for the negative direction of travel:

```
MINU  L   KB  60     OVERRIDE 60%
      T   QB  67
      L   KF  -360
      T   QW  68     INTEGER DIGITS
      L   KF  +600
      T   QW  70     DECIMAL DIGITS
      BE
```

FB 8/FB 9: Automatic mode/Automatic single block mode
In both cases, enter the number of the mode in QB 64 and the number of the traversing program in QB 66.

FB 8 - NAME:MO8



Invoking mode 8 with traversing program 5

```
L   KB  8
T   QB  64
L   KB  5
T   QB  66
BE
```

FB 9 - NAME:MO9

Invoking mode 9 with traversing program 5

```
L   KB  9
T   QB  64
L   KB  5
T   QB  66
BE
```

The traversing program for mode 8 and mode 9

As an example, the following traversing program is used to approach three positions; drilling is started at these positions via an M function.

Traversing program %5	*Subroutine L6*	The first step in main program %5 is the approach to start position 0 (100 mm), where, for example, a workpiece can be placed on the worktable. The table is then to be brought to the starting position for the drilling procedure. Subroutine L6 executes three times. Dwells simulate the drilling operation, which • is enabled with M30 and • disabled with M40. After drilling, the drive is brought back to position 0. The M99 function initiates removal of the workpiece from the table.
N01 G00 X100 M00 N02 G04 F50 N03 G91 N04 280 F200 N05 G24 F3 N06 L6 N07 G20 N08 G00 X100 M00 N09 G04 F50 M99 N10 M02	N01 X20 F100 N02 G04 F100 M30 N03 G04 F100 M40 N04 M02	

"External start enable" switch

The "External start enable" switch must be wired as an NC contact. The IP 266 will accept no jobs until it receives a "1" signal. In FB 26, this signal is scanned and routed via Q 2.0 to pin 7 on the IP 266's terminal block.

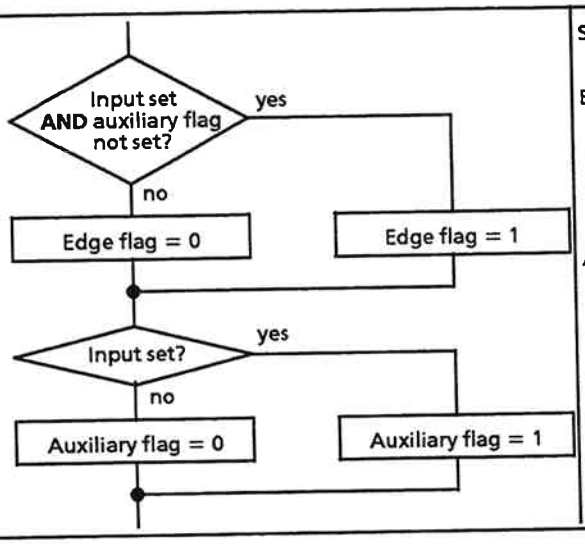
Selecting the functions for the different modes via IB 3

Not all functions are allowed in all modes. To preclude errors due to selection of an invalid function, the program in FB 26 checks the function for validity. If the RLO is 1 (valid function), the program branches to the relevant "Command FB".

Function	Command FB	For mode
START	FB 21	5, 6, 8, 9
STOP	FB 22	All modes
FWD/REV	FB 23	2
TRANSFER	FB 24	2, 9

The table above lists only the modes programmed in the sample program.
Refer to Table 6-3 in Section 6.6.2 for a list of all modes and their functions.

Every "Command FB" includes the following code-evaluation routine:



Setting auxiliary flags and edge flags

Edge flags

```
A     I 3.1
AN    F 4.0
=     F 4.1
```

Auxiliary flags

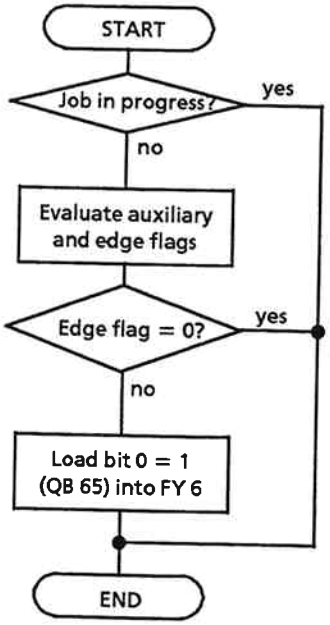
```
A     I 3.1
=     F 4.0
```

This routine works with auxiliary flags and edge flags, and ensures that a command is entered in the output byte only once in the first cycle that follows setting of the input. Edge flag 4.1 is used for this purpose.

0th cycle	Switch/key is actuated	Frame
1st cycle	Input appears in the PII as being set Auxiliary flag = 1 Edge flag = 1	→ is entered in output byte
2nd to nth cycle	Input remains set Auxiliary flag = 1 Edge flag = 0	→ is not entered in output byte

The edge flag for programming the TOGGLE bit is also required (FB 25/FB 26).

FB 21 - NAME:START



Programming the auxiliary and edge flags for the START function

Job in progress → abort

```
AN  I   66.7
BEC
```

Programming the edge and auxiliary flags

```
A   I   3.1     START KEY
AN  F   4.0
=   F   4.1     EDGE FLAG
A   I   3.1     START KEY
=   F   4.0
```

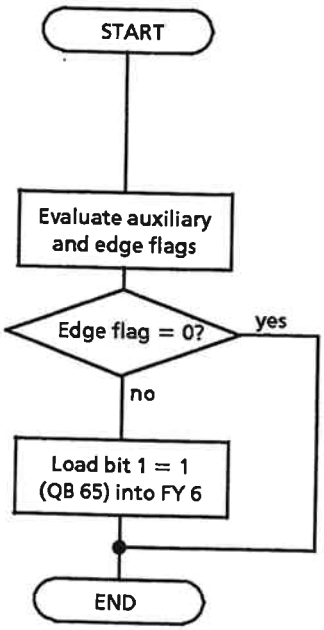
Edge flag not yet set → abort

```
AN  F   4.1
BEC
```

Load Start command

```
L   KB  1       START COMMAND
T   FY  6
BE
```

FB 22 - NAME:STOP



Programming the auxiliary and edge flags for the STOP function

Program auxiliary and edge flags

```
A   I   3.2     STOP KEY
AN  F   4.2
=   F   4.3     EDGE FLAG
A   I   3.2     STOP KEY
=   F   4.2
```

Edge flag not yet set → abort

```
AN  F   4.3
BEC
```

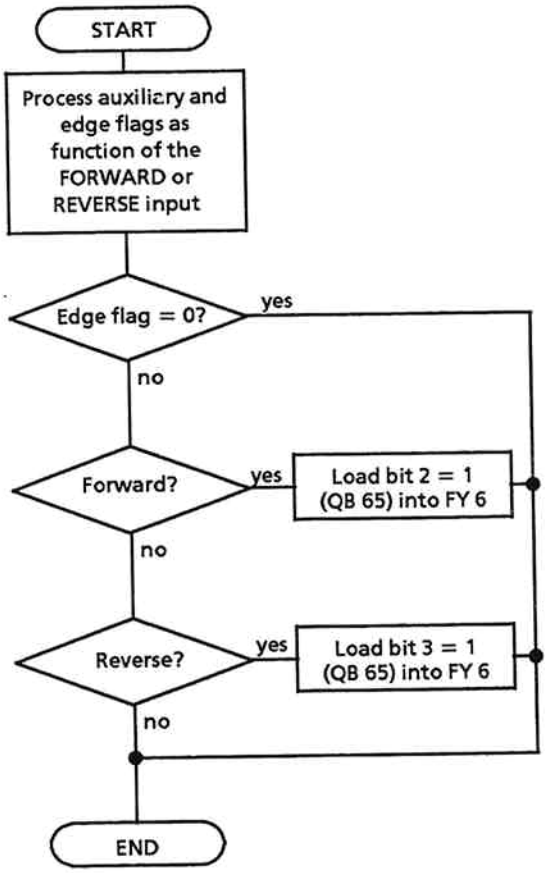
Load Start command

```
L   KB  2       STOP COMMAND
T   FY  6
BE
```

FB 23 - FORWARD/REVERSE

Two inputs are scanned in this FB to gather the information required to program the auxiliary and edge flags. The inputs for FORWARD and REVERSE are ORed.

FB 23 - NAME: FWDREV



Programming the auxiliary and edge flags for the FWD/REV functions

Programming the edge and auxiliary flags

```
      O   I   3.3     FORWARD
      O   I   3.4     REVERSE
      AN  F   4.4
      =   F   4.5
      O   I   3.3     FORWARD
      O   I   3.4     REVERSE
      =   F   4.4
```

Edge flag not yet set → abort

```
      AN  F   4.5
      BEC
```

Jump in dependence on the keys for FWD and REV

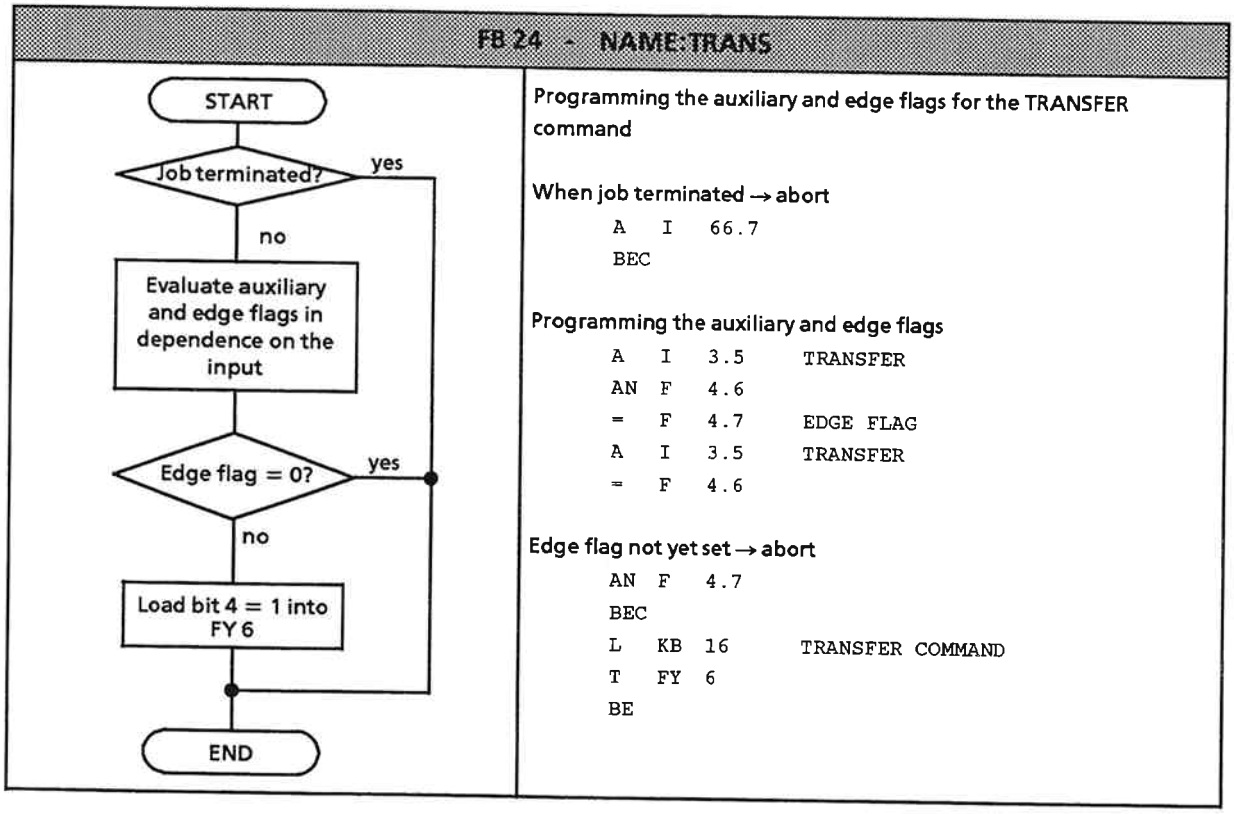
```
      A   I   3.3
      JC  =M001
      A   I   3.4
      JC  =M002
      BEU
```

Load start command

```
M001  L   KB  4       FWD command
      T   FY  6
      BEU
M002  L   KB  8       REV command
      T   FY  6
      BE
```

FB 24 - TRANSFER

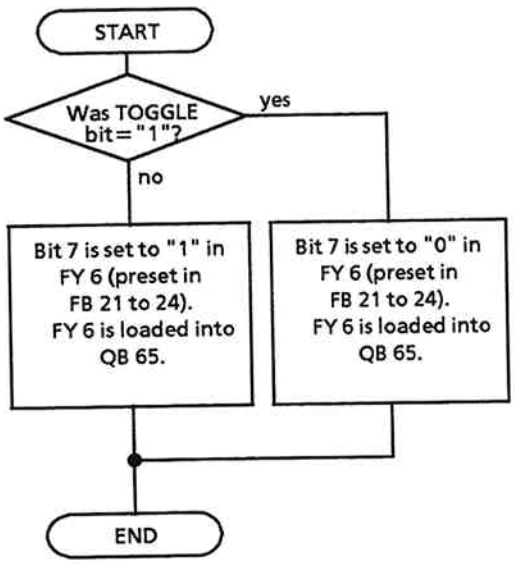
In the example, the TRANSFER command is allowed only as long as the job is not yet "TERMINATED". It is used to forward a speed modification (override) or start a traversing program block in Single Block mode.



FB 25 - TOGGLE bit

The TOGGLE bit must be inverted to enable the IP 266 to recognize a job as being a new job. If the nth job was started with TOGGLE = "1", job n + 1 must be started with TOGGLE = "0". In FB 25, the STEP 5 operations AW and OW were used to invert the TOGGLE bit.

FB 25 - NAME: TOGGLE



Programming the TOGGLE bit: Inverting the bit from the preceding job

Scanning the TOGGLE bit from the preceding job

```
      A   Q     65.7
      JC =INVT
```

TOGGLE bit was "0"; invert TOGGLE bit in command flag byte FY 6

```
      L   FY  6
      L   KH  0080    TOGGLE BIT "1"
      OW
      T   QB  65
      BEU
```

TOGGLE bit was "1"; invert TOGGLE bit in command flag byte FY 6

```
INVT  L   FY  6
      L   KH  007F    TOGGLE BIT "0"
      AW
      T   QB  65
      BE
```

FB 25 is invoked only if a command edge flag was set (in FB 21 to FB 24).

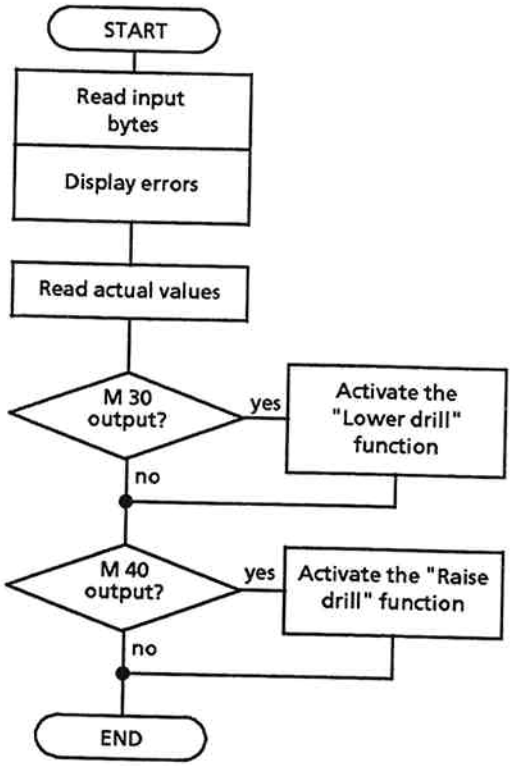
FB 20 - Read actual values

The IP 266 provides three modes for reading out IP data (see Section 5).
The default mode is mode 71, which is used to read the actual position.
Since mode 71 is to be used in the example, it need not be explicitly started. In contrast to the other modes, modes 71 to 73 can also be started while the axis is traversing ("Running" status).
The first part of the program in FB 20 displays the errors flagged in IB 67.

Reading of the input frame (PII) is only outlined. In practice, you would program the response to specific system states to suit your particular requirements.
One practice-based application has been programmed in the function block. Using M functions, you can trigger external activities

such as lower drill (M 30 in the example)
raise drill (M 40 in the example)

FB 20 - NAME:READ



Reading the mode, M function and status byte and displaying errors

```
L   IB  64      MODE
L   IB  65      M FUNCTION
L   IB  66      STATUS
L   IB  67      ERRORS
T   QB  5       DISPLAY
```

Reading the integer and decimal digits

```
L   IW  68      INTEGER DIGITS
L   IW  70      DECIMAL DIGITS

L   IB  65
L   KB  30      M30
!=F             LOWER DRILL
=   Q   2.6     ==> LOWER DRILL

L   IB  65
L   KB  40      M40
!=F             RAISE DRILL
=   Q   2.7     ==> RAISE DRILL
BE
```

9.5 Sample Program 2: Traversing to Two Fixed Target Positions

A second sample program is to be written to move the drive from one fixed target position to another in "Relative increment" mode. At each of the two fixed target positions, the direction of travel is to be reversed and a new positioning operation started.

- **Example**

Flags	Is used as
M 3.0	Edge flag

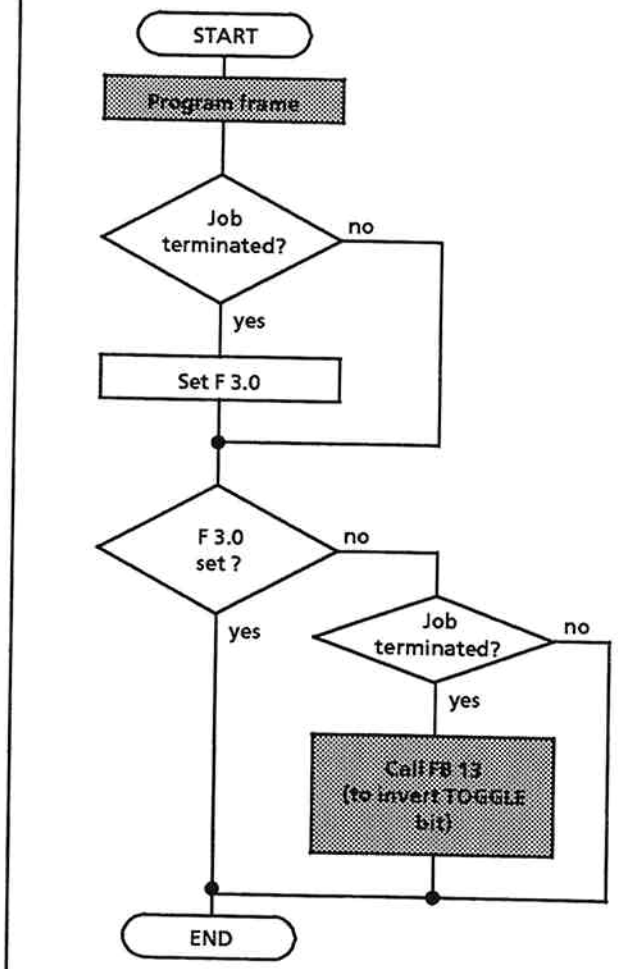
Flag bit 3.0 must be set to start a positioning operation. This bit ensures that a mode can be started only when the Job Terminated bit has been set for this operation.
To start the first operation, the bit must be set "externally", e.g. via an input.
You must scan this input in OB 1.

You can take basic functions, such as the wait loop for the IP runup and mode 99 for synchronizing the IP 266, from sample program 1. This means that you can use OB 22, FB 27, OB 1 and FB 10.

In OB 1, FB 11 must be invoked in place of FB 26.
The description of FB 11 includes only the automatic sequence controlled by this function block.

In FB 11, flag 3.0 is set in dependence on the Job Terminated bit. If this flag is not set, FB 11 is simply exited. If it is set, and if the "Job Terminated" bit is also set in the input byte, FB 11 invokes the function block used to invert the TOGGLE bit.

FB 11 - NAME:CONTROL



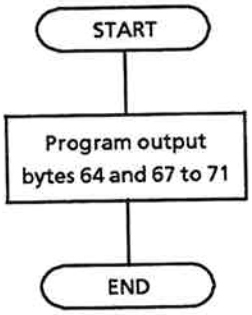
Program the input frame for mode 7, including the mode, the override factor and the distance:

```
        JU   FB  12
NAME    LOAD
```

Check to see whether a new job is allowed and, if so, invoke FB 13:

```
        AN   I   66.7
        S    F   3.0
        AN   F   3.0
        JC   =END
        A    I   66.7
        JC   FB  13
NAME    TOGGLE
END     BE
```

FB 12 - NAME:LOAD



Mode 7 requires the following data:

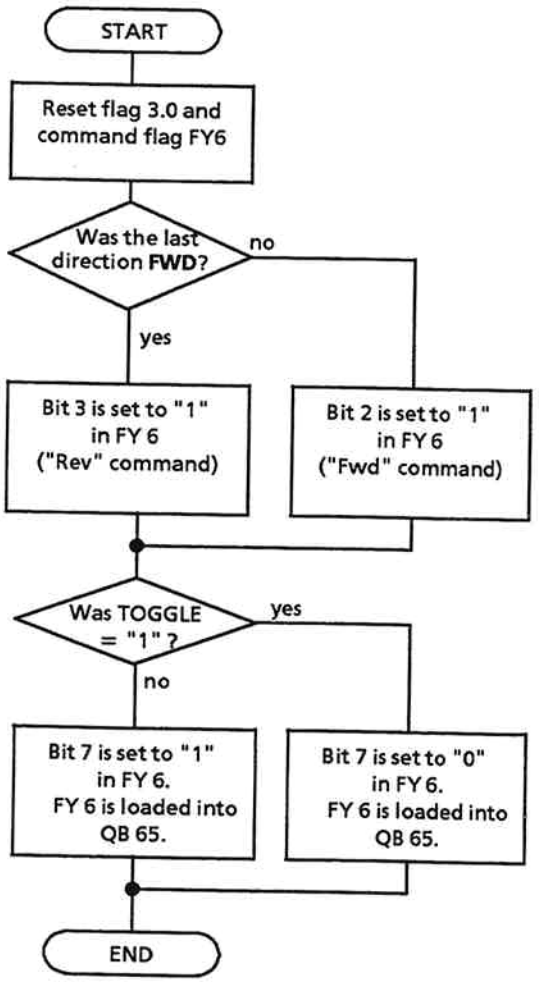
- Mode number in QB 64
- Override factor in QB 67
- Relative distance specification in bytes QB 68 to QB 71
- "Forward" or "Reverse" command in QB 65

```
L   KF  +7
T   QB  64
L   KF  +100
T   QB  67
L   KF  +50
T   QW  68
L   KF  +0
T   QW  70
BE
```

These specifications define a distance of 50.000 mm.
Like the TOGGLE bit, the command is alternately set and reset in FB 13.

When a job request is allowed and the output frame has been programmed, the start command must be loaded into QB 65 and the TOGGLE bit inverted.

FB 13 - NAME:TOGGLE



Inverting the direction of travel in dependence on the last traversing operation.

```
      A    F   3.0
      R    F   3.0
      L    KH  0
      T    FY  6
      A    Q   65.2
      S    F   6.3
      JC   =   CONT
      S    F   6.2
```

Inverting the TOGGLE bit and transferring the command byte to the output frame.

```
CONT: A    Q   65.7
      JC   =   INVT
      L    FY  6
      L    KH  0080
      OW
      T    QB  65
      BEU
INVT: L    FY  6
      L    KH  007F
      AW
      T    QB  65
      BE
```

"Automatic" positioning sequence as per example 2

State 1: Job terminated and flag 3.0=0; no job initiated, drive is at a standstill:
Motor must be started by setting F 3.0 to "1".

State 2: Job terminated and flag 3.0=1:
The TOGGLE FB is entered and a new mode preset.

State 3: Job terminated and flag 3.0=0, but no job order has been initiated: Loops are run through but no activities performed.

State 4: Job in progress and flag 3.0=0:
Flag 3.0 is set to "1", thus making it possible to issue a new job request. The only condition that has not yet been met to enable a new job to be started is the "Job terminated" bit from the IP 266's input message.

The next possible state is the same as state 2. Alternate positioning in a positive and negative direction must be programmed in the TOGGLE FB.

Summary:
The example enables generation of a new job request only when the "Job terminated" bit has been read. It is thus unnecessary to terminate an old job with STOP before starting a new one.

- Condition for issuing a new request:
  Job terminated and F 3.0=1
- Condition for setting flag bit F 3.0 to "1":
  Job in progress

Once the automatic sequence has been started, positioning continues until the FB 11 call has been deactivated in OB 1.

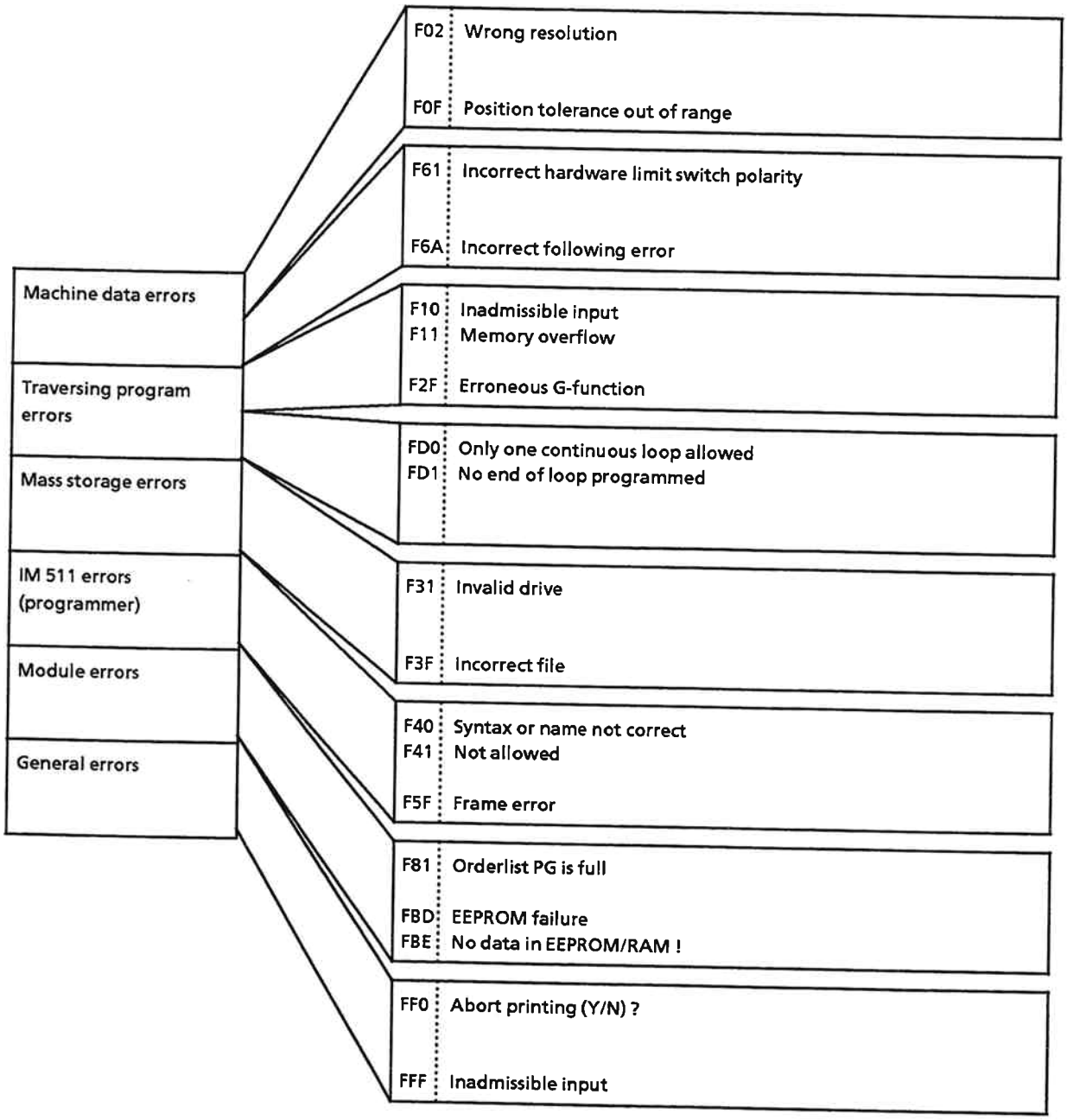
10	Troubleshooting	
10.1	Types of Error	10- 1
10.2	List of Errors and Possible Causes	10- 3

10 Troubleshooting

This section provides detailed information on the errors which may occur when using the IP 266. During direct communication between the PLC's CPU and the IP 266, the error code is forwarded in KH (hexadecimal constant) format. When you service the IP 266 via COM 266, the error code and the associated text are displayed on the monitor's error line.
The error codes flagged on the PLC are identical to those displayed by COM 266.

10.1 Types of Error

To simplify troubleshooting, this section provides a complete list of error codes and the associated error texts.


Machine data errors
Traversing program errors
Mass storage errors
IM 511 errors (programmer)
Module errors
General errors
F02 Wrong resolution
F0F Position tolerance out of range
F61 Incorrect hardware limit switch polarity
F6A Incorrect following error
F10 Inadmissible input
F11 Memory overflow
F2F Erroneous G-function
FD0 Only one continuous loop allowed
FD1 No end of loop programmed
F31 Invalid drive
F3F Incorrect file
F40 Syntax or name not correct
F41 Not allowed
F5F Frame error
F81 Orderlist PG is full
FBD EEPROM failure
FBE No data in EEPROM/RAM !
FF0 Abort printing (Y/N) ?
FFF Inadmissible input

10.2 List of Errors and Possible Causes

Due to the exceptionally large number of errors which may be flagged on the PLC, it is necessary to have at hand a comprehensive list showing the error message for each error code. This list begins on the next page. In some cases, information has also been provided on measures for error recovery. For each error listed you will find a cross-reference to one or more sections in the manual; these sections provide more detailed information on the error in question.

<table>
<tr><th>Error Code</th><th>Recovery Procedures</th><th>Cross-reference</th></tr>
<tr><td>F02</td><td>Wrong resolution
The resolution must lie in the range from 0.1 to 99.9, and is computed as follows:
$A = \frac{\text{Travel per encoder revolution}}{\text{Pulses per encoder revolution}}$
The unit of resolution depends on the parameter specification. You must take into account that the dimensional unit of resolution is always
$\frac{\text{Basic unit}/1000}{\text{Pulses}}$
<table><tr><th>Basic unit</th><th>Resolution</th></tr><tr><td>mm
0.1 inch
deg</td><td>µm
0.0001 inch
0.001 deg</td></tr></table></td><td>Section 5.1.2</td></tr>
<tr><td>F03</td><td>Wrong maximum speed
The speed specification must lie in the range from 1 to 65000.</td><td>Section 5.1.4</td></tr>
<tr><td>F04</td><td>Wrong JOG/INC speed
All speeds must be ≥ 1 and ≤ of the specified maximum speed.</td><td>Section 5.1.4</td></tr>
<tr><td>F05</td><td>Wrong reference speed
For the IP 266, reference speed 1 must be ≥ 1 and ≤ the specified maximum speed. Reference speed 2 must also be > 1, but ≤ reference speed 1.
1 ≤ reference speed 2 ≤ reference speed 1 ≤ maximum speed.</td><td>Section 5.1.4</td></tr>
<tr><td>F06</td><td>Wrong acceleration
The maximum acceleration must be ≥ 10 and ≤ 9999 mm/s^2 (0.1 inch/s^2, deg/s^2). The remaining acceleration/deceleration values must also be ≥ 10 but ≤ the maximum acceleration rate.</td><td>Section 5.1.5</td></tr>
</table>

Error Code	Recovery Procedures	Cross-reference
F07	**Wrong software limit switch** The traversing range of a linear axis is defined by the coordinates of the "Software start limit switch" and the "Software end limit switch". These two coordinates may not be identical (that of the start limit switch must always be lower than that of the end limit switch) and must lie in the range from +/- 32767.999 mm (+/- 3276.799 inches, +/- 32767.999 degrees).	Section 5.1.3
F08	**Wrong reference point** The reference point coordinate must be ≤ the coordinate of the "software end limit switch" and ≥ the coordinate of the "software start limit switch".	Section 5.1.3 Section 5.3.5
F09	**V_{max} is too low** The low limit of the programmed maximum speed depends on the resolution A [µm/pulse] ("travel per encoder revolution"/"pulses per encoder revolution"). V_{max} must be greater than 4 · A [µm/pulse].	
F0A	**Loop gain too low** The low limit of the KV factor is 0.1 [1/sec].	Section 5.1.6
F0B	**Loop gain too high** The loop gain (KV factor) must be less than 100 [1/sec], but not so high that a voltage corresponding to the maximum speed is output for a system deviation of 1 pulse, i.e. the loop gain in 1/sec must be less than $\frac{V_{max}\,[mm/min] \cdot 1000}{A\,[\mu m/pulse] \cdot 60}$	Section 5.1.6
F0C	**Wrong module number** When <F1> (Start) is pressed in the PRESETS form, the COM 266 software executes a module identification test. When a set of machine data is entered on the IP 266, the specified module number is compared with the module number in the machine data. The machine data must contain the same number as the one entered.	Section 5.1.1
F0D	**Zero offset too large** Every zero offset may assume values in the range +/-32767.999 mm. Among other things, a zero offset changes the coordinates of the software limit switches. Each offset value must be such that the coordinates of the software limit switches still lie in the range from +/-32767.999 mm (+/-32767.999 inches, +/-32767.999 degrees) after being shifted.	Section 5.1.7

Error Code	Recovery Procedures	Cross-reference
F0E	**Wrong tool offset** A tool offset is restricted to +/-32767.999. The coordinate of the software end limit switch plus zero offset and the coordinate of the software start limit switch plus zero offset must lie in the range +/-32767.999 mm (+/-32767.999 inches, +/-32767.999 degrees). Remember that the zero offset is a signed value. In the case of a rotary axis, the tool offset must also lie within the traversing range.	Section 5.1.7
F0F	**Position tolerance out of range** The tolerance range for zero-speed monitoring extends from 0.001 to 64.999 mm, and must also be less than the maximum following error.	Section 5.1.6
F10	**Inadmissible input**	
F11	**Memory overflow**	Section 5.4
F12	**Separate functions with blanks**	Section 5.4.2
F13	**Program already exists**	Section 5.4
F14	**Block syntax incorrect**	Section 5.5.4
F15	**Field cannot be exited**	Section 5.4
F16	**Terminate processing?**	Section 5.4
F17	**End function already present**	Section 5.4.2
F18	**Input after L-function prohibited**	Section 5.4.2
F19	**X-function not present**	Section 5.4.2
F1A	**Input after last entry prohibited**	Section 5.4.2
F1B	**Limit value of the function exceeded**	Section 5.4.2
F1C	**X-function incorrect → correction**	Section 5.4.2
F1D	**Insert prohibited**	Section 5.4.2 Section 6
F1E	**Not stored → Machining (traversing) program incomplete**	Section 5.4
F1F	**Output impossible → file DB-No. not identical**	Section 5.4

Error Code	Recovery Procedures	Cross-reference
F20	Block type inadmissible	Section 5.4
F21	Function key inhibited → block incomplete	Section 5.4
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F23	No other functions with L-function. Delete?	Section 5.4
F24	Error in F-function	Section 5.4
F25	Block type missing	Section 5.4
F26	Block number missing	Section 5.4
F27	Block complete → Function key	Section 5.4
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F29	X-function must be followed by F-function	Section 5.4
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F2C	Erroneous L-function	Section 5.4
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F33	Element list missing	
F34	Data block missing	
F35	DB or file already exists	
F36	DB or file missing	
F37	File exists	
F38	Drive (floppy) write protected	
F39	File write protected	
F3A	New element too long	
F3B	Too many elements	
F3C	File missing	
F3D	Directory full	

Error Code	Recovery Procedures	Cross-reference
F3E	**Disk full**	
F3F	**Incorrect file**	
F40	**Syntax or name not correct**	
F41	**Not allowed**	
F42	**Data block missing**	
F43	**Overwrite data block?**	
F44	**Data block missing**	
F45	**Delete data block?**	Section 6
F46	**Deleted!**	
F48	**Illegal value!**	
F4C	**Cable not connected!**	
F50	**Data block missing**	
F51	**Cable not connected to PG**	
F52	**Memory on PCB (module) too small**	
F53	**Watchdog error PCB** This error is flagged over the programmer interface, i.e. in COM 266 and in those situations in which it is not possible to communicate with the positioning module. This error is flagged in the following instances: - The cable is not connected or is improperly connected - The positioning module has no power supply	
F54	**Transmission (transfer) error**	
F55	**Erroneous data transfer**	
F56	**Erroneous data transfer**	
F57	**BREAK received**	
F58	**PCB (module) does not answer**	
F5A	**Wrong baudrate**	
F5D	**Parity error**	
F5E	**Overflow error**	
F5F	**Frame error**	

Error Code	Recovery Procedures	Cross-reference
F61	**Incorrect hardware limit switch polarity** The only permissible values are "0" (NO contact, positive) and "1" (NC contact, negative). The IP 266 can detect an invalid parameter value only when neither hardware limit switch is actuated at the instant at which the machine data is entered. The hardware limit switches are also evaluated when a rotary axis is used. If none have been connected, NO contacts must be programmed.	
F62	**Maximum speed too high for this resolution** When a 5V encoder is used, the counter chip can count pulse trains with a maximum baud rate of 500 kHz. At the specified maximum speed in conjunction with the specified resolution [µm/pulse], this value is exceeded.	
F66	**Invalid range limit value** This error occurs only in conjunction with a rotary axis. The cause of error is the same as that for error F07.	Section 5.1.3
F68	**Invalid dimensional unit** Permissible dimensional units are millimeters, inches and degrees.	
F69	**Backlash compensation out of range** The backlash compensation value must be in the range 0.001 to 64.999 mm.	Section 5.1.7
F6A	**Following error out of range** The following error must be in the range 0.001 to 99.999.	Section 5.1.6
F81	**(Job) orderlist PG is full** Because of the sluggishness of its mechanical parts, the module cannot process job orders as fast as these can be issued. The last job order issued via the programmer or PLC is lost, and must be retried.	
F82	**Inadmissible order** The last job order from the PLC or programmer contained either an undefined mode or was meaningless at this point. Example: An attempt to start an axis that was already traversing. The order is ignored.	
F83	**Block stored** This error is flagged only in mode 10 (TEACH-IN).	Section 5.3.10
F84	**Axis operational → no inputs possible**	
F85	**(Job) orderlist PLC is full** Coincides with error F81, but for the PLC. The last job order must be reissued.	
F86	**High-speed change and final block** The selected mode cannot be started because of a "0" signal at the "external start enable" digital input.	Section 2.5.4

Error Code	Recovery Procedures	Cross-reference
F87	**Speed range exceeded** Either the override factor is not within the range 1% to 200% or the speed selected via (valid) override factor exceeds the maximum speed. This error occurs only in jog modes 1 and 2 and in incremental mode. The positioning module automatically prevents exceeding of these limiting values.	Section 5.1.4
F8A	**Reference point missing**	Section 5.3.5
F8B	**Max. following error exceeded** The maximum following error specified in the machine data was exceeded and the current operation is aborted with a deceleration ramp. The position control loop remains in force and the axis does not reach zero speed until the following error has been reduced. The following-error monitor is not activated unless the maximum following error is exceeded despite axis movement or the actual value no longer changes and the specified maximum following error is such that it is exceeded at an analog voltage of less than 5 volts. Possible causes: - Load torque too high - Acceleration rate too high - Loop gain too low - Value specified as maximum following error too low In these four cases, the axis can be moved in controlled jog mode. The machine data must be adapted accordingly. - The machine data specifications for maximum speed and resolution are incorrect, i.e. were not matched to one another. This can be checked by comparing the speed specified for controlled jog mode with the displayed speed.	Section 5.1.6
F8C	**Wrong PCB (module) number** Once the positioning module contains at least one correct machine data record, it is no longer possible to change the module number. The number stored can be viewed in COM 266's PRESETS form.	
F8D	**Data block missing**	
F8E	**Wrong or no machine data**	
F8F	**Erroneous machine data**	

Error Code	Recovery Procedures	Cross-reference
F90	PG is offline	Section 6.1.3.
F91	Overwrite machine data?	
F92	Program No. limit reached	Section 5.4
F93	Data block missing	
F94	Overwrite machining (traversing) program?	
F95	Automatic prohibited	
F97	Stroke limit exceeded (traversing range exceeded)	Section 5.1.3
F98	Program stroke limit exceeded (not enough room for traversing program)	Section 5.4
F99	Left limit switch tripped	Section 5.1.3
F9A	Right limit switch tripped	Section 5.1.3
F9B	External STOP occurred	Section 2.5.3
F9C	Lower software switch tripped	Section 5.1.3
F9D	Upper software switch tripped	Section 5.1.3
F9E	Operating mode prohibited in Teach-In Only jog modes 1 to 3 and increment modes 6 and 7 are permitted in Teach-In mode.	Section 5.3.10
F9F	Erroneous operating mode processed	
FA0	Standstill (zero-speed) monitor tripped	Section 5.1.6
FA1	Watch-Dog	Section 5.3.18
FA2	Watch-Dog	Section 5.3.18
FA3	Error at block start	
FA4	Sub-program DB-No too large The DB number must lie in the range from 1 to 255.	
FA5	G-function prohibited	Section 5.5.4
FA6	Loop only as outer loop	
FA7	Nesting depth exceeded	Section 5.4.2
FA8	Wrong X-function	Section 5.4.2
FA9	Wrong F-function	Section 5.4.2
FAA	Stroke too long (traversing path too long)	
FAB	Machining speed too high (traversing speed too high)	

Error Code	Recovery Procedures	Cross-reference
FAC	**Error at block end**	
FAD	**End of program precedes end of loop**	Section 5.4.2
FAE	**Block not permitted after flying change**	Section 5.4.2
FB0	**Machining program erroneous (error in traversing program)**	Section 5.4
FB1	**Machining (traversing) program already exists! Change Prog-No?**	
FB2	**Invalid position control direction** The encoder's position control direction is checked on an IP 266 cold restart. If an error is detected, the IP starts mode 4. You must then switch off the IP 266's 24 V power supply and change the position control direction (see Section 3.4). If no error was detected following a positioning operation during which an analog voltage greater than 5 V was output, the IP 266 deactivates the position control monitor. The monitor is reactivated each time mode 4 is started.	
FB3	**Machining program is active**	
FB5	**Target position not yet reached** The setpoint position is already within the target range. The actual position is still outside the tolerance range of the zero-speed monitor and is no longer approaching the target coordinate, and the following error is lower than the specified maximum. Possible causes: - The tolerance range of the zero-speed monitor is too small - The gain factor is too low or - The power section has too much drift (drift compensation, mode 18) - The position control loop was interrupted during execution of a traversing operation, and the distance to go is less than the maximum following error. If the distance to go is greater, however, "Maximum following error exceeded" is flagged.	
FB6	**Error in position control loop** There is no change in the actual position even though the analog voltage (setpoint speed) exceeds 5 V. The current operation is aborted and mode 4 (follow-up mode) automatically started. In follow-up mode, the position controller is off. Follow-up mode can be terminated at any time. The position controller is then reenabled. Possible causes: - Encoder not connected, incorrectly connected or defective - The module's analog output is not wired - The power section is not switched on or not enabled - The axis is blocked by an obstacle of some kind or is jammed.	

Error Code	Recovery Procedures	Cross-reference
FB7	PLC failure	
FB8	Invalid path specification	
FB9	Invalid tool offset	Section 5.1.7
FBA	Invalid G function for dimensional unit "degrees"	Section 5.4.2
FBB	Path specification not in BCD code	
FBC	EEPROM not programmable!	
FBD	EEPROM failure!	
FBE	No data in EEPROM/RAM !	
FD0	Only one continuous loop permitted	
FD1	No end of loop	Section 5.4.2
FEC	Printing	
FED	Printer not ready!	
FEF	Printing aborted!	
FF0	Abort printing (Y/N)?	
FF2	Printer not initialized! COM 266 takes the printer parameters from S5-DOS to print data. When this error is flagged, exit COM 266 and initialize the printer interface with S5-DOS.	
FF4	'*' is not allowed here!	
FF5	Tilde (~) stands for 'to the power of 2'	
FF6	Invalid mode	Section 5.3
FF7	Invalid time entered	Section 6.1.3
FF8	No plant designation entered	Section 6.1.3
FF9	No filename entered	Section 6.1.3
FFA	DB stored	
FFB	Last page!	Section 6.9
FFC	Key prohibited	
FFD	HELP key not allowed here!	
FFE	Exit COM266?	
FFF	Inadmissible input	

A Active and Passive Faults in Automation Equipment/ Guidelines for Handling Electrostatic Sensitive Devices (ESD)

A Active and Passive Faults in Automation Equipment / Guidelines for Handling Electrostatic Sensitive Devices

Active and Passive Faults in Automation Equipment

- Depending on the particular task for which the electronic automation equipment is used, both **active** as well as **passive** faults can result in a **dangerous** situation. For example, in drive control, an active fault is generally dangerous because it can result in an unauthorized startup of the drive. On the other hand, a passive fault in a signalling function can result in a dangerous operating state not being reported to the operator.

- The differentiation of the possible faults and their classification into dangerous and non-dangerous faults, depending on the particular task, is important for all safety considerations in respect to the product supplied.

Warning

In all cases where a fault in automation equipment can result in severe personal injury or substantial property damage, i.e., where a dangerous fault can occur, additional external measures, additional external measures must be taken or equipment provided to ensure or force safe operating conditions even in the event of a fault (e.g., by means of independent limit monitors, mechanical interlocks, etc.).

Procedures for Maintenance and Repair

If you are carrying out measurement or testing work on an active unit, you must adhere to the rules and regulations contained in the "VGB 4.0 Accident Prevention Regulations" of the German employers liability assurance association ("Berufsgenossenschaften"). Pay particular attention to paragraph 8, "Permissible exceptions when working on live parts."

Do not attempt to repair an item of automation equipment. Such repairs may only be carried out by **Siemens service personnel or repair shops Siemens has authorized to carry out such repairs.**

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Guidelines for Handling Electrostatic Sensitive Devices (ESD)

What is ESD?

All electronic modules are equipped with large-scale integrated ICs or components. Due to their design, these electronic elements are very sensitive to overvoltages and thus to any electrostatic discharge.

These **E**lectrostatic **S**ensitive **D**evices are commonly referred to by the abbreviation **ESD.**

Electrostatic sensitive devices are labelled with the following symbol:

Caution

Electrostatic sensitive devices are subject to voltages that are far below the voltage values that can still be perceived by human beings. These voltages are present if you touch a component module without previously being electrostatically discharged. In most cases, the damage caused by an overvoltage is not immediately noticeable and results in total damage only after a prolonged period of operation.

Electrostatic charging of objects and persons

Every object with no conductive connection to the electrical potential of its surroundings can be charged electrostatically. In this way, voltages up to 15000 V can build up whereas minor charges, i.e. up to 100 V, are not relevant.

Examples:

• Plastic covers	up to 5000 V
• Plastic cups	up to 5000 V
• Plastic-bound books and notebooks	up to 8000 V
• Desoldering device with plastic parts	up to 8000 V
• Walking on plastic flooring	up to 12000 V
• Sitting on a padded chair	up to 15000 V
• Walking on a carpet (synthetic)	up to 15000 V

Limits for perceiving electrostatic discharges

An electrostatic discharge is

- perceptible from 3500 V
- audible from 4500 V
- visible from 5000 V

A fraction of those voltages is capable of destroying or damaging electronic devices.

Carefully note ad apply the protective measures described below to protect and prolong the life of your modules and components.

General protective measures against electrostatic discharge damage

- Keep plastics away from sensitive devices. Most plastic materials have a tendency to build up electrostatic charges easily.
- Make sure that the personnel, working surfaces and packaging are sufficiently grounded when handling electrostatic sensitive devices.
- If possible, avoid any contact with electrostatic sensitive devices. Hold modules without touching the pins of components or printed conductors. In this way, the discharged energy cannot affect the sensitive devices.

Additional precautions for modules without housings

Note the following measures that have to be taken for modules that are not protected against accidental contact:

- Touch electrostatical sensitive devices only
  - if you wear a wristband complying with ESD specifications or
  - if you use special ESD footwear or ground straps when walking ona an ESD floor.
- Persons working on electronic devices should first discharge their bodies by touching grounded metallic parts (e.g. bare metal parts of switchgear cabinets, water pipes, etc.)
- Protect the modules against contact with chargeable and highly insulating materials, such as plastic foils, insulating table tops or clothes made of plastic fibres.
- Place electrostatic sensitive devices only on conductive surfaces:
  - Tables with ESD surfaces
  - Conductive ESD foam plastic (ESD foam plastic ismostly coloured black)
  - ESD bags
- Avoid direct contact of eletrostatic sensitive devices with visual display units, monitors or TV sets (minimum distance to screen $>$ 10 cm).

The following Figures once again illustrates the precautions for handling electrostatically sensitive devices.

a Conductive flooring material
b Table with conductive, grounded surface
c ESD footwear
d ESD smock
e Gounded ESD writstband
f Grounded connection of switchgear cabinet
g Grounded chair

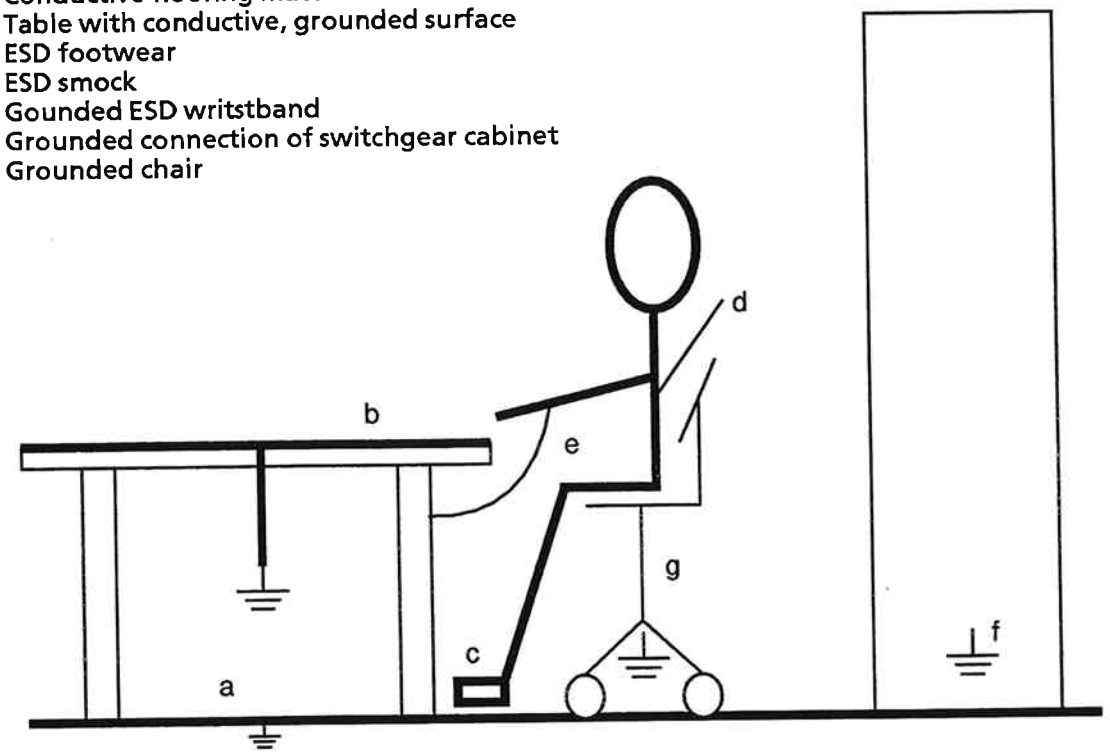

Figure A-1. ESD Measures

Taking measurements and working on ESD modules

Measurements may be taken on electrostatic sensitive devices only if

- the measuring device is grounded (e.g. via protective conductor) or
- the tip of the isolated measuring tool has previously been discharged (e.g. by briefly touching grounded metal parts).

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