SIEMENS

SIMATIC

S7-300 Programmable Controller Integrated Functions CPU 312 IFM/314 IFM

Manual

EWA 4NEB 710 6058-02a

Edition 2

Safety Guidelines

This manual contains notices which you should observe to ensure your own personal safety, as well as to protect the product and connected equipment. These notices are highlighted in the manual by a warning triangle and are marked as follows according to the level of danger:

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

draws your attention to particularly important information on the product, handling the product, or to a particular part of the documentation.

Qualified Personnel

The device/system may only be set up and operated in conjunction with this manual.

Only **qualified personnel** should be allowed to install and work on this equipment. Qualified persons are defined as persons who are authorized to commission, to ground, and to tag circuits, equipment, and systems in accordance with established safety practices and standards.

Correct Usage

Note the following:

Warning

This device and its components may only be used for the applications described in the catalog or the technical description, and only in connection with devices or components from other manufacturers which have been approved or recommended by Siemens.

This product can only function correctly and safely if it is transported, stored, set up, and installed correctly, and operated and maintained as recommended.

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Siemens AG
Automation Group
Industrial Automation Systems
P.O. Box 4848, D-90327 Nuremberg

Disclaimer of Liability

We have checked the contents of this manual for agreement with the hardware and software described. Since deviations cannot be precluded entirely, we cannot guarantee full agreement. However, the data in this manual are reviewed regularly and any necessary corrections included in subsequent editions. Suggestions for improvement are welcomed.

Technical data subject to change.

Siemens Aktiengesellschaft

Order No. 6ES7 398-8CA00-8BA0

Preface

Purpose

The information in this manual enables you to solve automation tasks with the integrated functions of the CPU 312 IFM or CPU 314 IFM.

Audience

This manual is addressed to users who wish to use the integrated functions of the CPU 312 IFM/CPU 314 IFM

Users will find the following information:

- Basic information on the integrated functions
- A description of the Frequency Meter, Counter, Counter A/B and Positioning integrated functions
- The technical specifications of the integrated functions
- The use of the integrated functions with the OP3.

The hardware of the CPUs and the S7-300 modules is described in the manuals *S7-300 Programmable Controller, Installation and Hardware and S7-300, M7-300 Programmable Controllers, Module Specifications.*

Scope of this Manual

This manual is valid for:

CPU	Order No.	From Product Versions
CPU 312 IFM	6ES7 312-5AC01-0AB0	01
CPU 314 IFM	6ES7 314-5AE02-0AB0	01

This manual describes the integrated functions contained in the CPU 312 IFM and CPU 314 IFM at the date of issue of the manual. We reserve the right to describe modifications to the integrated functions in a separate Product Information.

Changes From the Previous Version

Compared to the previous version, the manual *Integrated Functions* with the order number 6ES7 398-8CA00-8BA0, this manual has been extended with a description of the new features of the Frequency Meter integrated function.

Approbations

The following approbations exist for the S7-300:

UL-Recognition-Mark
Underwriters Laboratories (UL) in accordance with
Standard UL 508, File No. 116536

CSA-Certification-Mark
Canadian Standard Association (CSA) in accordance with
Standard C22.2 No. 142, File No. LR 48323

CE Mark

Our products conform to the requirements of EC Directive 89/336/EEC "Electromagnetic Compatibility" and the harmonized European standards (ENs) listed therein.
The EU certificates of conformity are held at the disposal of the competent authorities in accordance with the above-named EC directive, Article 10, at the following address:

Siemens Aktiengesellschaft
Bereich Automatisierungstechnik
A & D AS E 14
Postfach 1963
D-92209 Amberg
Federal Republic of Germany

Recycling and Disposal

The SIMATIC S7-300 is an environmentally-friendly product!
The SIMATIC S7-300 is characterized by the following points:

- The housing plastic is equipped with halogen-free flameproofing despite its high level of fireproofing.
- Laser labeling (that is, no paper labels)
- Plastics materials labeled in accordance with DIN 54840
- Reduction in materials used thanks to more compact design, fewer components thanks to integration in ASICs

The SIMATIC S7-300 can be recycled thanks to the low level of pollutants in its equipment.

Please contact the following address for environmentally-friendly recycling and disposal of your old SIMATIC equipment:

Siemens Aktiengesellschaft
Technische Dienstleistungen
ATD TD 3 Kreislaufwirtschaft
Postfach 32 40
D-91050 Erlangen

Telephone: ++49 9131/7-3 36 98
Fax: ++49 9131/7-2 66 43

This Siemens service department provides a comprehensive and flexible disposal system with customized advice at a fixed price. After disposal, you receive a breakdown of the dismantling procedure with information on the proportions of materials and the relevant material record documentation.

Scope of the Documentation Package

The documentation should be ordered separately from the CPU:

CPU	Documentation
CPU 312 IFM or CPU 314 IFM	• *S7-300 Programmable Controller, Installation and Hardware* Manual • *S7-300 and M7-300 Programmable Controllers, Module Specifications* Reference Manual • *S7-300 Programmable Controller* Instruction List
	• *Integrated Functions CPU 312 IFM/314 IFM* Manual

In Appendix F , you will find a list of documentation which you require for programming and starting up of the S7-300.

CD-ROM

You can also order the entire SIMATIC S7 documentation as SIMATIC S7 reference documentation on CD-ROM.

How to Use This Manual

This manual features the following access aids for fast reference to specific information:

- The manual starts with a complete table of contents, also including a list of all figures and tables appearing in the manual.
- In the various chapters, the headlines on the left margin highlight the contents of the particular section.
- The glossary in the last chapter of the Appendix explains important terms employed in the manual.
- The index at the end of this manual enables you to get fast access to the information required.

Additional Assistance

If you have any queries about the products described in this manual, please contact your local Siemens representative. You can find the addresses of Siemens representatives in the Appendix “Siemens Worldwide” of the manual *S7-300 Programmable Controller, Installation and Hardware*.

If you have any questions or suggestions concerning this manual, please fill in the form at the end of this manual and return it to the specified address. Please feel free to enter your personal assessment of the manual in the form provided.

We offer a range of courses to help get you started with the SIMATIC S7 programmable controller. Please contact your local training center or the central training center in Nuremberg, D-90327 Germany, Tel. +49 911 895 3154.

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Product Overview 1

In this Chapter

1.1 Introduction to the Integrated Functions

Possible Solutions for Your Automation Task

For counting, frequency measurement and positioning axes, the SIMATIC S7-300 provides the following 3 possible solutions:

- User program (*STEP 7* operations)
- Integrated functions of the CPU 312 IFM/CPU 314 IFM
- Function modules for counting, frequency measurement and positioning axes

Integrated Functions

The integrated functions are a permanent component of the CPU 312 IFM/ CPU 314 IFM. The inputs and outputs of the integrated functions are hardwired to the integrated inputs/outputs of the CPU.

CPU 312 IFM

The CPU 312 IFM provides the following:

- Frequency Meter integrated function
- The Counter integrated function (up and down counter)

CPU 314 IFM

The CPU 314 IFM provides the following:

- Frequency Meter integrated function
- Counter integrated function (1 up and 1 down counter)
- Counter A/B integrated function (2 up and 2 down counters, A and B)
- Positioning integrated function (open-loop positioning)

Properties of the Integrated Functions

The integrated functions operate in parallel to the user program and extend the cycle time of the CPU only minimally. The integrated functions access the integrated inputs/outputs of the CPU direct. The Counter and Counter A/B integrated functions can initiate process interrupts.

You can operate and control the integrated functions with an operator panel (OP), programming device or PC.

If you use an OP3, standard displays are provided for the integrated functions (see Appendix G).

Selection Criteria

In Table 1-1, you will find a comparison of the three possible solutions to your automation task with the main selection criteria:

Table 1-1 Selection Criteria for the Automation Task

Selection Criteria	User Program	Integrated Functions	Function Modules
Direct link to the inputs/out-puts	No	Yes	Yes
Increase in cycle time	Yes	Minimal	No
Suitability for different applications	Low	Medium (50% of solu-tions)	High (95% of solu-tions)
Performance in relation to response time	Low	Medium	High
Handling of process errors (e.g. wire break)	No	Limited	Yes

The Integrated Functions Solution

You can use the integrated functions as a low-cost solution to automation tasks which do not require the performance capabilities of a function module.

Examples of Frequency Meter Integrated Function

The following examples illustrate the possible applications of the Frequency Meter integrated function:

- Measurement of the rotation speed of a shaft with monitoring of the permissible speed range
- Measurement of throughput (items per sample time) with range monitoring

Examples of the Counter and Counter A/B Integrated Functions

Below are some possible applications of the Counter and Counter A/B integrated functions:

- Counting a quantity with incoming and outgoing parts (up and down counting)
- Periodic quantity counting with parameterized responses when a comparison value is reached.

Examples of the Positioning Integrated Function

Below are some possible applications of the Positioning integrated function:

- Positioning workpieces on a conveyor belt with synchronization at the start of the workpiece
- Moving a worktable to several positions for machining of a workpiece

1.2 Integrated Functions on the CPU 312 IFM

Introduction

The integrated functions are connected to the automation process via the integrated inputs/outputs of the CPU 312 IFM.

Special Integrated Inputs/Outputs

The CPU 312 IFM is equipped with four special integrated inputs/outputs whose functionality can be adjusted. The following alternative settings are possible:

- 4 interrupt inputs (digital inputs)
- 4 digital inputs for the Counter integrated function
- 1 digital input for the Frequency Meter integrated function and 3 standard digital inputs

Integrated inputs/outputs not used for the integrated function can be used as standard digital inputs/outputs.

Integrated Inputs/ Outputs

The integrated inputs/outputs of the CPU 312 IFM are illustrated in Figure 1-1. The special integrated inputs/outputs are highlighted in gray.

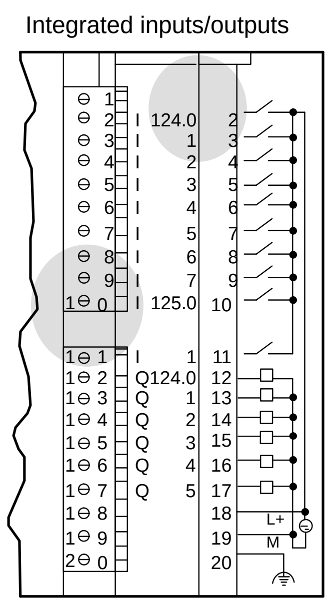

Figure 1-1 Integrated Inputs/Outputs of the CPU 312 IFM for Integrated Functions

1.3 Integrated Functions on the CPU 314 IFM

Introduction

The integrated functions are connected via the integrated inputs/outputs of the CPU 314 IFM with the automation process.

Special Integrated Inputs/Outputs

The CPU 314 IFM is equipped with four special integrated inputs/outputs whose functionality can be adjusted. The following alternative settings are possible:

- 4 interrupt inputs (digital inputs)
- 4 digital inputs for the Counter integrated function
- 4 digital inputs for the Counter A/B integrated function
- 1 input for the Frequency Meter integrated function and 3 standard digital inputs
- 3 digital inputs for the Positioning integrated function and 1 standard digital input

Integrated inputs/outputs not used for the integrated function can be used as standard digital inputs/outputs.

Integrated Inputs/Outputs

Figure 1-2 shows the integrated inputs/outputs of the CPU 314 IFM. The special integrated inputs/outputs are shaded in gray.

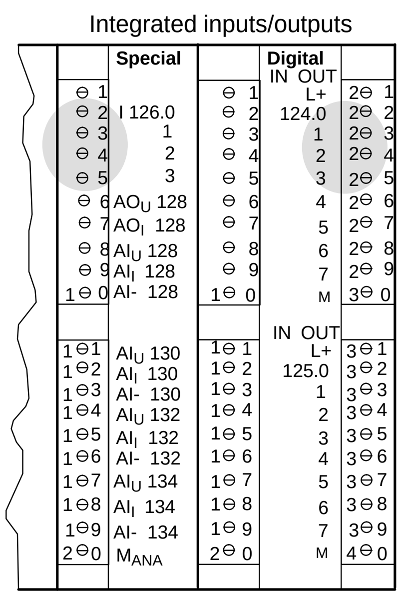

Figure 1-2 Integrated Inputs/Outputs of the CPU 314 IFM for Integrated Functions

1.4 Guide through the Manual for Successful Implementation of an Integrated Function

Preconditions

For the successful implementation of an integrated function, we assume that

- You know how to use the *STEP 7* programming package.
- You are familiar with the hardware of the CPU 312 IFM or CPU 314 IFM.

  The scope and operation of the *STEP 7* programming package are described in various manuals. You will find a list of the manuals with a brief description of the contents in Appendix F. The hardware of the CPUs and the range of modules are described in the manuals *S7-300 Programmable Controller, Installation and Hardware* and *S7-300, M7-300 Programmable Controllers, Module Specifications*.

Guide

In Table 1-2, you will find the operations that you will perform step-by-step in order to start up an integrated function, and the section in the manual which you should read.

Table 1-2 Guide through the Manual

Step	Operation	Read about the Integrated Function			
		Frequency Meter	Counter	Counter A/B	Positioning
1	Acquire basic knowledge on the behavior and handling of the integrated functions	Chapter 2			
2	Parameterize integrated function	Section 3.4	Section 4.4	Section 5.4	Section 6.3
3	Wire integrated function	Section 3.5	Section 4.5	Section 5.5	Section 6.6
4	Program CPU • Assign system function block • Evaluate process interrupts	Section 3.6 -	Section 4.6 Section 4.8	Section 5.6 Section 5.8	Section 6.7 -
5	Switch CPU from STOP to RUN	–			
6	Test the integrated function	Section 2.5			
7	Determine the cycle and response time	Section 3.9	Section 4.9	Section 5.9	Section 6.9

Application Examples

Sections 3.10, 4.10 and 6.10 of this manual contain practice-oriented application examples of the integrated functions which will be of special benefit to the first-time SIMATIC S7 user. The application examples have an extremely simple structure and guide the user from the definition of the task through wiring and parameterizing of the integrated function right up to the user program.

What you Should Know about the Integrated Functions

2

In this Chapter

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2.1 How the Integrated Functions are Included in the CPU 312 IFM/ CPU 314 IFM

Inclusion

Figure 2-1 shows the inclusion of the integrated functions in the CPU using the CPU 312 IFM as an example. An explanation is provided in the text following Figure 2.1.

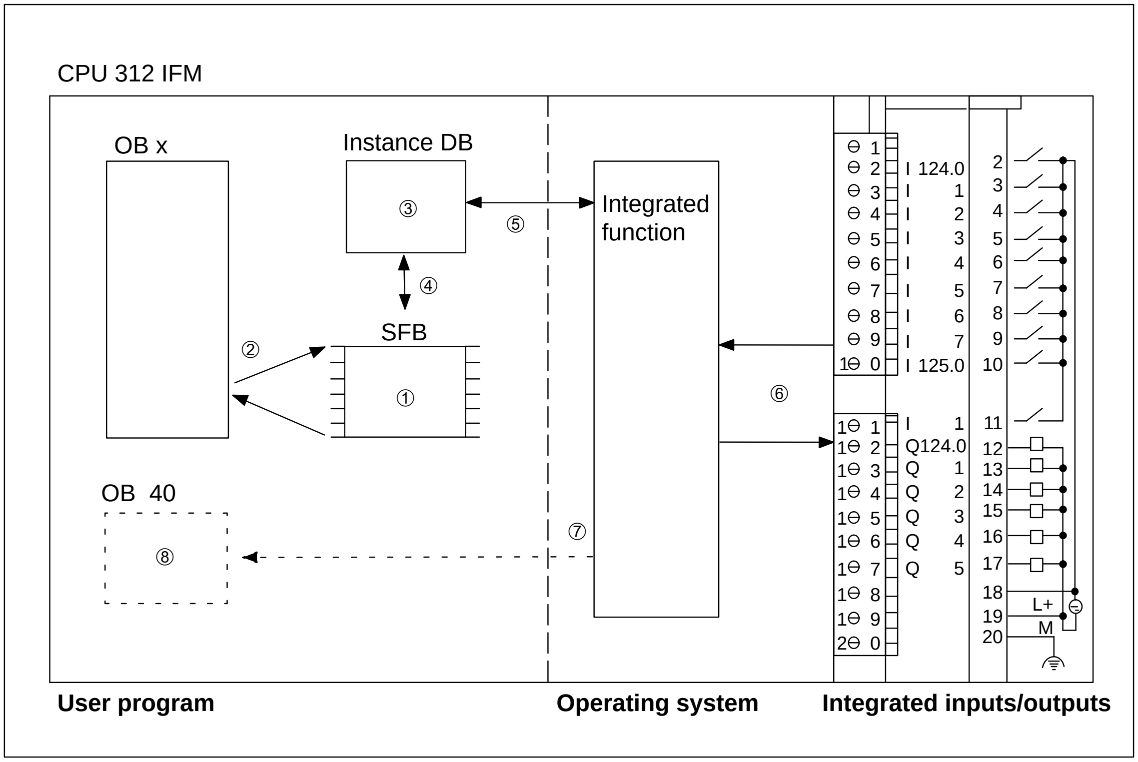

Figure 2-1 Inclusion of the Integrated Functions in the CPU 312 IFM

Description

The integrated functions are a component of the operating system on the CPU 312 IFM.

When you have assigned the parameters for an integrated function with *STEP 7*, the integrated function is activated.

Table 2-1 contains a description of Figure 2-1.

Table 2-1 Inclusion of the Integrated Functions in the CPU 312 IFM

No.	Description
①	A system function block (SFB) is assigned to each integrated function. The SFBs are integrated in the CPU.
②	The SFB is called from an organization block (OB) in the user program.
③	The instance DB contains the data which are exchanged between the user program and the integrated function.
④	The SFB writes data to the instance DB and reads data from the instance DB.
⑤	An integrated function writes to and reads from the instance DB: • At the cycle control point (if parameterized with *STEP 7*) • On operating mode transitions • When the SFB is called
⑥	An integrated function accesses the integrated inputs/outputs directly without a detour via the user program. This ensures the lowest response times.
⑦	The Counter and Counter A/B integrated functions can initiate a process interrupt if an event occurs.
⑧	The user program provides a rapid response to the event in OB 40 (interrupt OB).

2.2 How to Include the Integrated Function in the User Program

Including an Integrated Function

You can use either the STL editor or the LADDER editor under STEP 7 to include an integrated function in your user program. The use of STEP 7 is described in the user manual *Standard Software for S7 and M7, STEP 7*.

Preconditions

You must already have defined the number of the instance DB in *STEP 7*. The instance DB must also already exist in your user program.

Calling the SFB

The SFB for the integrated function can be called from the user program:

- From any organization block (for example, OB 1, OB 40, OB 100)
- From any function block (FB)
- From any function (FC)

Points to Remember when Calling the SFB

When the SFB is called, input EN (enable) of the SFB must be set, to allow the SFB to be processed (see Section 3.6, for example).

Some of the SFB inputs of the integrated functions are edge-controlled. These inputs trigger a reaction when a positive signal edge change takes place.

If you do not call the SFB inputs cyclically in the user program, you can generate a positive edge change on the edge-controlled inputs by calling the SFB twice:

- On the first call, you set the edge-controlled inputs to “0”.
- On the second call, you set the edge-controlled inputs to “1”.

To find out which SB inputs are edge-controlled, see Sections 3.6, 4.6, 5.6 and 6.7 for each integrated function.

Interrupting the SFB

The SFB cannot be interrupted from higher-priority program execution levels (for example, OB 40). A process interrupt is not executed, for example, until the SFB in OB 1 has been processed. This increases the interrupt response time on the CPU by the time taken to execute the SFB.

2.3 Functions and Properties of the Instance DB

Data Management

The instance DB contains the data which are exchanged between the user program and the integrated function.

Operator Interface

An operator panel (OP) can be connected to a CPU 312 IFM/CPU 314 IFM without a user program. The SFB does not have to be called, because the operator panel accesses the instance DB direct (requirement with the CPU 314 IFM: If you have parameterized updating at the cycle control point with *STEP 7*; see Section 3.4).

Retentivity

An integrated function is retentive if, following a power failure, it continues to operate with the status it had immediately before the power failure occurred.

Configuring Retentivity

If the integrated function is to be "retentive", you must configure the instance DB as retentive with *STEP 7*.

The parameters for the CPU 312 IFM/CPU 314 IFM are described in the manual *S7-300 Programmable Controller, Installation and Hardware* in the section entitled "Retentive Areas". How to work with *STEP 7* is described in the *Standard Software for S7 and M7, STEP 7* User Manual.

Contents of the Instance DB

The instance DB contains the states of all input and output parameters of the assigned SFB.

The integrated function accesses the inputs and outputs of the integrated inputs/outputs of the CPU 312 IFM directly. The states of these inputs and outputs are not stored in the instance DB.

Updating the Instance DB

The instance DB is updated at the following times:

- On operating mode transitions on the CPU
- At the cycle control point (if you have parameterized updating at the cycle control with *STEP 7*; see Section 3.4)
- When the corresponding SFB is called

2.4 How to Activate and Configure the Integrated Functions

Introduction

To use an integrated function, you must first activate and then assign the parameters for the integrated function.

Activation/ Configuration

You activate and assign the parameters for the integrated function off-line on a programming device or PC with *STEP 7*. How to work with *STEP 7* is described in the *Standard Software for S7 and M7, STEP 7* User Manual.

“Functions” Register

When parameterizing the CPU with *STEP 7* in the “Functions” register, activate **one** of the following integrated functions:

- **for CPU 312 IFM:**
  - Interrupt Inputs
  - Counter
  - Frequency Meter
- **for CPU 314 IFM:**
  - Interrupt inputs
  - Counter
  - Parallel counter A/B
  - Frequency Meter
  - Positioning

Description of Parameters

You will find a description of the parameters and their value ranges in:

- The *S7-300 Programmable Controller, Installation and Hardware* Manual for the interrupt inputs
- Section 3.4 for the Frequency Meter integrated function
- Section 4.4 for the Counter integrated function
- Section 5.4 for the Counter A/B integrated function
- Section 6.3 for the Positioning integrated function

2.5 How to Test the Integrated Functions

Introduction

The CPUs provide test functions with which you can monitor and modify data and variables of the user program.

Test Functions

Table 2-2 contains the test functions you can use for the CPU 312 IFM and CPU 314 IFM.

Table 2-2 Test Functions for CPU 312 IFM and CPU 314 IFM

Test Functions	Use
Status Variable	Monitor the status of selected process variables (inputs, outputs, bit memories, timers, counters, data) at a defined point in the user program
Modify Variable	Assign a value to selected process variables (inputs, outputs, bit memories, timers, counters, data) at a defined point in the user program in order to control the user program.
Status Block	Monitor a block during program execution to assist in the elimination of problems that arise during the compilation of the user program. Status Block presents the status of various elements of the status word, accumulators and registers, in order to indicate which of the operations are active.

Using the Test Functions

The test functions “Status Variable” and “Modify Variable” are described in the user manual *Standard Software for S7 and M7, STEP 7*.

You will find a description of the “Status Block” test function in the manual *Statement List (STL) for S7-300 and S7-400, Programming* or in the manual *Ladder Logic (LAD) for S7-300 and S7-400, Programming*, depending on which programming language you are using.

2.6 How the Integrated Functions Behave on Operating Mode Transitions on the CPU

Preconditions

You have activated and assigned the parameters for the integrated function with *STEP 7*.

Operating Modes

The behavior of the integrated functions depends directly on the operating mode of the CPU (START, STOP and RUN). Table 2-3 describes the behavior of the integrated functions in the various operating modes of the CPU.

Table 2-3 Operating Mode of the CPU

	START	STOP/HOLD	RUN
Integrated function	inactive	inactive	active
Standard function block (for example, SFB 30)	callable	not callable	callable
Updating the instance DB	when SFB is called	No	at the cycle control point (if parameterized with STEP 7) and when SFB is called
Process interrupts	disabled	disabled	enabled
Inputs of integrated inputs/outputs	are not evaluated by the integrated function	are not evaluated by the integrated function	are evaluated by the integrated function
Outputs of integrated inputs/outputs	are not affected by the integrated function	are not affected by the integrated function	are affected by the integrated function

Operating Mode Transitions

Figure 2-2 illustrates the operation mode transitions of the CPU and the associated actions of the integrated function.

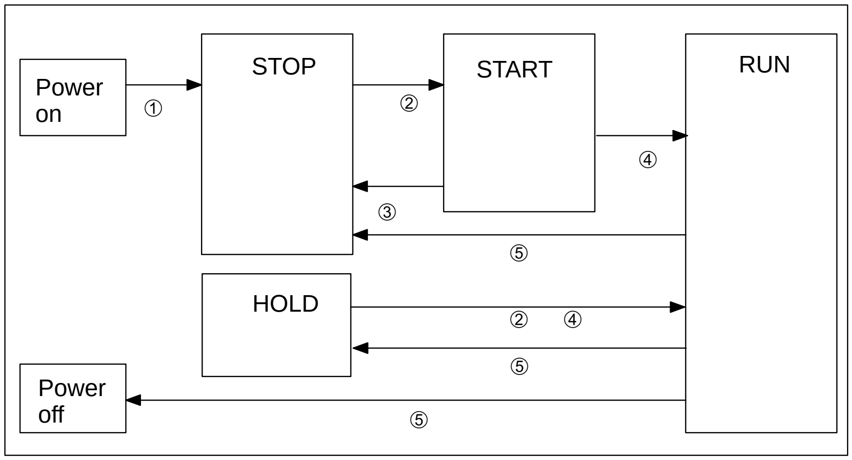

Figure 2-2 Operating Mode Transitions

Description of the Actions

The actions of the operating mode transitions are described in Table 2-4.

Table 2-4 Operating Mode Transitions

Action	Description
①	The parameters of the integrated function are checked for completeness and the value range is verified.
②	Initialization of edge-controlled inputs • The edge-controlled inputs are initialized such that the reaction is triggered on the next evaluation of the instance DB with input = 1.
③	If an error is detected during the start-up, the CPU switches to STOP mode.
④	Start integrated function (transition to active state) • The integrated function accepts the values from the instance DB and starts. • The outputs are enabled by the operating system. • The inputs are evaluated by the integrated function.
⑤	Stop integrated function • The output values are updated in the instance DB. • The edge-controlled inputs are reset in the instance DB.

Frequency Meter Integrated Function 3

Integrated Inputs/ Outputs

Table 3-1 lists the special integrated inputs/outputs of the CPU 312 IFM and CPU 314 IFM for the Frequency Meter integrated function.

Table 3-1 Overview: Integrated Inputs/Outputs for Frequency Meter Integrated Function on CPU 312 IFM and CPU 314 IFM

CPU 312 IFM	CPU 314 IFM	Function
I 124.6	I 126.0	Measurement digital input

Note

The CPU 312 IFM is used for examples in this chapter. The examples can be implemented in the same way using the CPU 314 IFM provided you take account of the other integrated inputs/outputs (see Table 3-1).

Chapter

3.1 Function Overview

Introduction

In this section, you will find an overview diagram (block diagram) for the Frequency Meter integrated function. The block diagram contains the main components of the integrated function and all its inputs and outputs.

Sections 3.2 and 3.3 refer to the block diagram. These sections describe the interaction of the main components of the Frequency Meter integrated function and their inputs and outputs.

Purpose of the Integrated Function

The Frequency Meter integrated function enables continuous measurement of a frequency $\leq$ 10 kHz.

Block Diagram

Figure 3-1 shows the block diagram for the Frequency Meter integrated function:

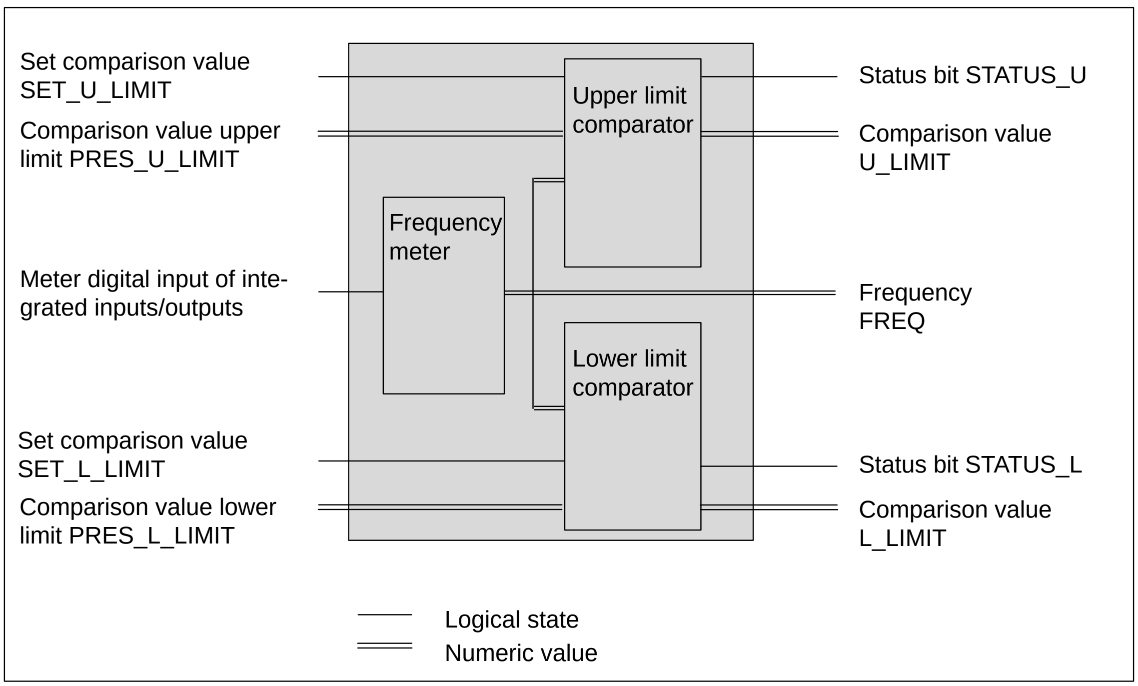

Figure 3-1 Block Diagram for Frequency Meter Integrated Function

3.2 How the Frequency Meter Integrated Function Operates

Frequency Meter

The Frequency Meter calculates the current frequency from the measured signal and the sample time.

The measured signal is connected via the Meter digital input of the integrated CPU inputs/outputs. The Frequency Meter counts the positive edges of the measured signal within a sample time in order to calculate the frequency.

Different Measuring Principles

The CPU calculates the frequency according to two different measuring principles:

- Measuring principle 1 is applied with a sample time of 0.1 s, 1 s or 10 s
- Measuring principle 2 is applied with a sample time of 1 ms, 2 ms or 4 ms

Measuring Principle 1

The Frequency Meter calculates the frequency according to the following formula:

$$\text{Frequency} = \frac{\text{Number of positive edges}}{\text{Sample time}}$$

Measuring Principle 2

The Frequency Meter calculates the frequency by measuring the time interval between two incoming positive edges at the meter’s digital input.

Sample Time

You configure the sample time with *STEP 7*. You can choose between a sample time of 1 ms, 2 ms, 4 ms, 0.1 s, 1 s or 10 s. The measurement process is restarted immediately after the sample time expires, with the result that the current frequency is always available.

Example

The sample time is 1 s. 6500 positive edges were counted during one sample period.

$$\text{Frequency} = \frac{6500}{1\ \text{s}} = 6500\ \text{Hz}$$

Properties of Measuring Principle 1

The sample times from 0.1 s to 10 s were introduced for the measurement of high frequencies. The higher the frequency, the more accurate the result of the measurement. With high frequencies, this measuring principle is associated with:

- High measurement accuracy
- Low load on the cycle

Properties of Measuring Principle 2

The sample times from 1 s to 4 s were introduced for the measurement of low frequencies. The lower the frequency, the more accurate the result of the measurement. With low frequencies, this measuring principle is associated with:

- High measurement accuracy
- High–speed response to process events (e.g. process interrupt triggering)
- A high load on the cycle

Display of First Valid Frequency Value

When the CPU is started or HOLD mode is deactivated, OB 1 is executed and the Frequency Meter integrated function is started simultaneously.

With measuring principle 1, the 1st valid frequency is calculated after the 1st sample period.

With measuring principle 2, the 1st valid frequency is calculated, at the latest, after twice the sample time or according to the formula 2 x 1/measured frequency (the larger of the two values applies).

With both measuring principles, the frequency is -1 until the valid frequency is calculated.

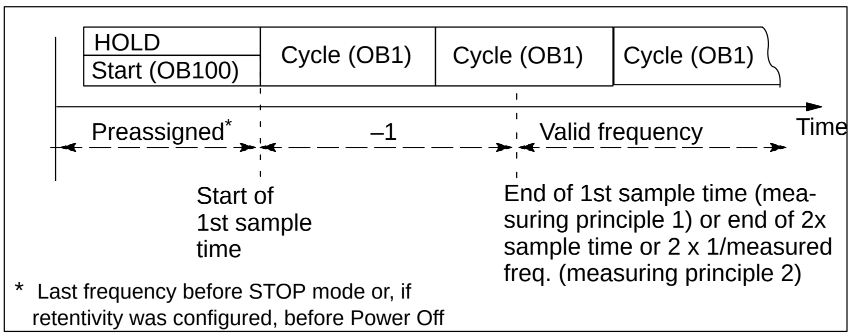

Figure 3-2 Display of First Valid Frequency Value

Limit Frequency Exceeded

The Frequency Meter integrated function is designed for a maximum frequency of 10 kHz.

Warning

If the current frequency exceeds the frequency limit of 10 kHz:

- Correct operation of the integrated function is no longer assured
- The cycle load is increased
- The process interrupt response time is increased
- Communication errors can arise (up to termination of the connection)

When the cycle time watchdog intervenes, the CPU switches to STOP.

3.3 Function of the Comparator

Comparator

The Frequency Meter integrated function has two integrated comparators with which you can monitor adherence to a specific frequency range.

Upper Limit Comparator

The upper limit comparator intervenes if the frequency FREQ exceeds a defined comparison value U_LIMIT. In this case, status bit STATUS_U at SFB 30 is enabled.

Lower Limit Comparator

The lower limit comparator intervenes if the frequency FREQ falls below a defined comparison value L_LIMIT. In this case, status bit STATUS_L at SFB 30 is enabled.

Evaluation of the Status Bits

You can evaluate the status bits in your user program.

Until the first valid frequency value is displayed, the signal state of the status bits at SFB 30 is 0.

Configurable responses with sample times of 1, 2 or 4 ms

If the value exceeds the U_LIMIT comparison value or falls below the L_LIMIT comparison value, a corresponding process interrupt is triggered if configured in *STEP 7* (sample time 1, 2 or 4 ms and process interrupt activated).

Function of the Comparator

Figure 3-3 illustrates the function of the comparator. The gray areas indicate when a lower or upper limit is exceeded.

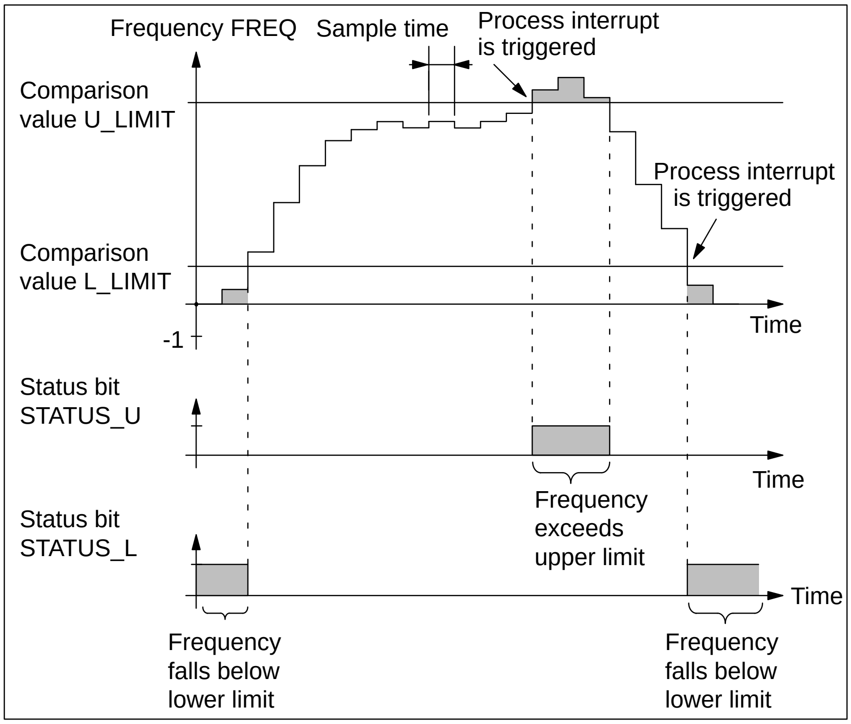

Figure 3-3 Function of the Comparator

Defining New Comparison Values

You can define new comparison values for the upper and lower limits in the input parameters PRES_U_LIMIT and PRES_L_LIMIT at SFB 30. The new comparison values are accepted by the comparator when positive edges occur on the input parameters SET_U_LIMIT or SET_L_LIMIT at SFB 30.

If, after defining a new comparison value for the upper/lower limit, the frequency exceeds or falls below this limit, a process interrupt is triggered (provided you have activated the process interrupt with *STEP 7*).

3.4 Assigning Parameters

Parameter Assignment with *STEP 7*

You assign the parameters for the integrated function with *STEP 7*. How to work with *STEP 7* is described in the manual *Standard Software for S7 and M7, STEP 7*.

Parameters and their Value Ranges

Table 3-2 lists the parameters for the Frequency Meter integrated function.

Table 3-2 "Integrated Inputs/Outputs" Parameter Block

Parameter	Description	Value Range	Default Setting
Number of instance DB	The instance DB contains the data which are exchanged between the integrated function and the user program.	1 to 63 CPU 314 IFM 1 to 127	62
Sample time	The sample time is the time interval in which the integrated function calculates a current frequency value.	0.1 s; 1 s; 10 s; 1 ms; 2 ms; 4 ms	1 s
Automatic updating at the cycle control point[1]	You determine whether the instance DBs of the integrated function are to be updated at the cycle control point	Activated/ deactivated	Activated
Value Falls Below Lower Limit			
Process interrupt[2]	You can set that a process interrupt is triggered if the actual value falls below the comparison value L_LIMIT.	Activated/ deactivated	Deactivated
Value Exceeds Upper Limit			
Process interrupt[2]	You can set that a process interrupt is triggered if the actual value exceeds the comparison value U_LIMIT.	Activated/ deactivated	Deactivated

1 Parameter can only be assigned in the CPU 314 IFM. In the CPU 312 IFM, the parameter is automatically activated

2 Process interrupt can only be set with configured sample times of 1, 2 and 4 ms

Measurement Resolution with Sample Times of 0.1 s, 1 s and 10 s

The measurement resolution increases with every increase in the sample time. Table 3-3 illustrates the relationship of the measurement resolution to the configured sample time.

Table 3-3 Measurement Resolution with Sample Times of 0.1 s; 1 s and 10 s

Sample Time	Resolution	Example of Positive Edges during 1 Sample Period	Frequency
0.1 s	The frequency can be calculated in 10 Hz steps	900	9000 Hz
		901	9010 Hz
1 s	The frequency can be calculated in 1 Hz steps	900	900 Hz
		901	901 Hz
10 s	The frequency can be calculated in 0.1 Hz steps	900	90 Hz
		901	90.1 Hz

Disadvantage of a Large Sample Time

The Frequency Meter calculates the frequency at larger intervals. This means a current frequency value is available less often when the sample time is large.

Measurement Accuracy with Sample Times of 0.1 s, 1 s and 10 s

The accuracy of measurement depends on the measured frequency and the sample time.

Table 3-4 shows the maximum measurement error at the frequency limit of 10 kHz with the configurable sample times.

Table 3-4 Measurement Accuracy with Sample Times of 0.1 s; 1 s and 10 s

Frequency	Sample Time	Maximum Measurement Error in % of Measured Value
10 kHz	0.1 s	1.1 %
10 kHz	1 s	0.11 %
10 kHz	10 s	0.011 %

Calculation of the Measurement Error with Sample Times of 0.1 s, 1 s and 10 s

You can use the following formula to calculate the maximum measurement error of your measured frequency:

$$\text{Max. error in \% of meas. val.} = \frac{0.001\text{ s} + \dfrac{1}{\text{Frequency in Hz}}}{\text{Sample time in s}} \times 100\ \%$$

Due to the measuring principle, the measurement error increases as the measured frequency decreases.

Measurement Resolution with Sample Times of 1 ms, 2 ms and 4 ms

The internal arithmetical resolution of the time measurement between two positive edges is always the same, i.e. =1 mHz, for a configured sample time of 1 ms, 2 ms or 4 ms.

Please note: Frequencies < 20 mHz cause a frequency value of 0 to be output.

Measurement Accuracy with Sample Times of 1 ms, 2 ms and 4 ms

The accuracy of measurement depends on the measured frequency and the sample time. The measurement accuracy increases as the frequency decreases and the sample time increases.

Table 3-5 shows the maximum measurement error at the frequency limit of 10 kHz with the configurable sample times.

Table 3-5 Meas. Accuracy with Sample Times of 1 ms; 2 ms & 4 ms

Frequency	Sample Time	Maximum Measurement Error in % of Measured Value
10 kHz	1 ms	5 %
10 kHz	2 ms	2 %
10 kHz	4 ms	1 %

Calculation of the Measurement Error with Sample Times of 1 ms, 2 ms and 4 ms

You can use the following formula to calculate the maximum measurement error of your measured frequency:

Max. error = $\pm$ frequency in Hz $\times$ factor in % / 100 $\pm$ 0.001 Hz

Factor in %

The factor used to calculate the measurement error in the above formula depends on the CPU.

The factor cannot exceed a maximum value. In other words, if the formula in the table below yields a factor for your application which is larger than the maximum factor, you must use the maximum factor in the formula in order to calculate the measurement error.

Table 3-6 Factor for Calculating the Max. Measurement Error for IF Frequency Meter

CPU	Formula for Factor Calculation	Max. Factor for Sample Time of:		
		1 ms	2 ms	4 ms
CPU 312 IFM	(0.01 + 0.0018 s $\times$ frequency in Hz) %	5 %	2 %	1 %
CPU 314 IFM	(0.01 + 0.0012 s $\times$ frequency in Hz) %	3.5 %	1.5 %	0.75 %

3.5 Connecting the Sensors to the Integrated Inputs/Outputs

Introduction

The CPU 312 IFM is used as a wiring example. The example can be implemented in the same way with the CPU 314 IFM using another integrated input/output (see Table 3-1).

Terminals

The terminals of the integrated inputs/outputs on the CPU 312 IFM for the Frequency Meter integrated function are listed in Table 3-7.

Table 3-7 Terminals for the Sensors (CPU 312 IFM)

Terminal	Identifier	Description
8	I 124.6	Meter
18	L+	Supply voltage
19	M	Ground

Terminal Connection Model

Figure 3-4 illustrates the connection of the sensor (for example, BERO) to the integrated inputs/outputs of the CPU 312 IFM

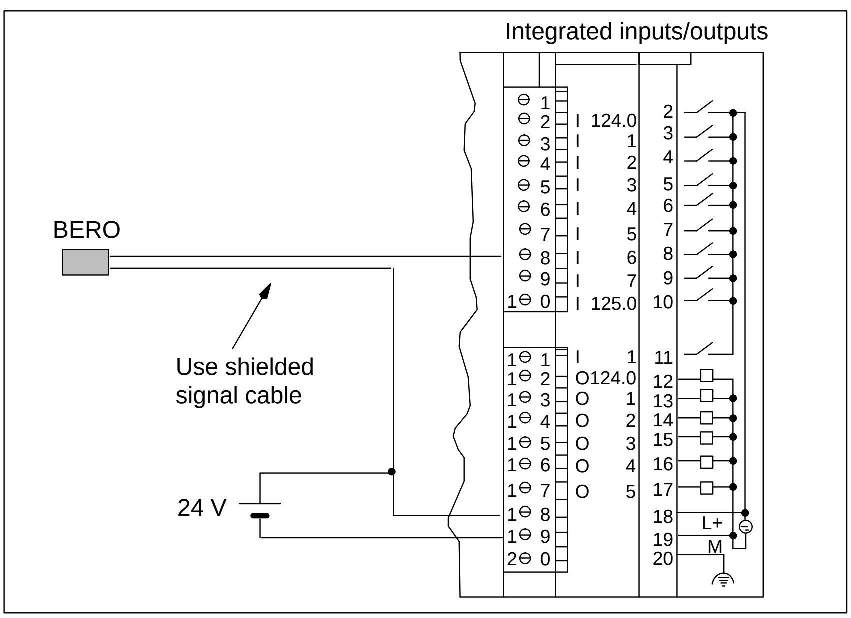

Figure 3-4 Sensor Wiring (CPU 312 IFM)

Shielding

You must use a shielded signal cable to connect the sensor and you must connect the cable shield to ground. Use the shield connecting element for this purpose.

You will find more detailed information on the installation of the cable shield in the manual *S7-300 Programmable Controller, Installation and Hardware*.

3.6 System Function Block 30

SFB 30

The Frequency Meter integrated function is assigned to SFB 30. A graphical illustration of SFB 30 is shown in Figure 3-5.

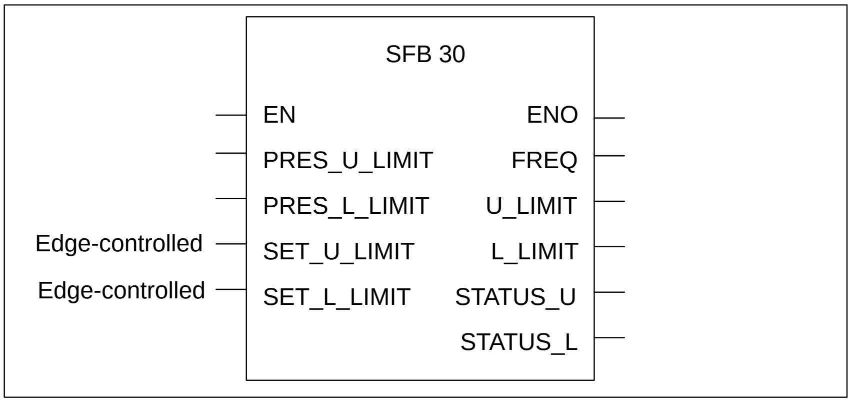

Figure 3-5 Graphical Illustration of SFB 30

Input Parameters of SFB 30

In Table 3-8 you will find a description of the input parameters of SFB 30.

Table 3-8 Input Parameters of SFB 30

Input Parameter	Description
EN	EN is the input parameter for enabling SFB 30. This input parameter causes the SFB to be executed. The input parameter has no effect on the execution of the integrated function. The SFB is executed as long as EN = 1. When EN = 0, the SFB is not executed. Data type: BOOL Address ID: I, Q, M, L, D Value range: 0/1 (FALSE/TRUE)
PRES_U_LIMIT	You can use this input parameter to store a new PRES_U_LIMIT comparison value. It is accepted following a positive edge on the input parameter SET_U_LIMIT. Data type: DINT Address ID: I, Q, M, L, D Value range: from -2147483648 to 2147483647
PRES_L_LIMIT	You can use this input parameter to store a new PRES_L_LIMIT comparison value. It is accepted following a positive edge on the input parameter SET_L_LIMIT. Data type: DINT Address ID: I, Q, M, L, D Value range: from -2147483648 to 2147483647
SET_U_LIMIT	Following a positive edge, comparison value PRES_U_LIMIT is accepted. The status bit STATUS_U is also set simultaneously in accordance with the new comparison value. Data type: BOOL Address ID: I, Q, M, L, D Value range: 0/1 (FALSE/TRUE)

Table 3-8 Input Parameters of SFB 30, continued

Input Parameter	Description
SET_L_LIMIT	Following a positive edge, comparison value PRES_L_LIMIT is accepted. The status bit STATUS_L is also set simultaneously in accordance with the new comparison value. Data type: BOOL Address ID: I, Q, M, L, D Value range: 0/1 (FALSE/TRUE)

Output Parameters of SFB 30

In Table 3-9 you will find a description of the output parameters of SFB 30.

Table 3-9 Output Parameters of SFB 30

Output Parameter	Description
ENO	Output parameter ENO indicates whether an error occurred during execution of the SFB. If ENO = 1, no error occurred. If ENO = 0, the SFB was not executed or an error occurred during execution. Data type: BOOL Address ID: I, Q, M, L, D Value range: 0/1 (FALSE/TRUE)
FREQ	The measured frequency is output in mHz in this parameter. Data type: DINT Address ID: I, Q, M, L, D Value range: from -1 to 10000000
U_LIMIT	The current U_LIMIT comparison value is output in this output parameter. Data type: DINT Address ID: I, Q, M, L, D Value range: from -2147483648 to 2147483647
L_LIMIT	The current L_LIMIT comparison value is output in this output parameter. Data type: DINT Address ID: I, Q, M, L, D Value range: from -2147483648 to 2147483647
STATUS_U	The output parameter STATUS_U indicates the position of the frequency relative to the comparison value U_LIMIT: • Frequency FREQ > comparison value U_LIMIT: output parameter STATUS_U enabled • Frequency FREQ ≤ comparison value U_LIMIT: output parameter STATUS_U not enabled Data type: BOOL Address ID: I, Q, M, L, D Value range: 0/1 (FALSE/TRUE)
STATUS_L	The output parameter STATUS_L indicates the position of the frequency relative to the comparison value L_LIMIT: • Frequency FREQ ≥ comparison value L_LIMIT: output parameter STATUS_L not enabled • Frequency FREQ < comparison value L_LIMIT: output parameter STATUS_L enabled Data type: BOOL Address ID: I, Q, M, L, D Value range: 0/1 (FALSE/TRUE)

3.7 Structure of the Instance DB

Instance DB of SFB 30

Table 3-10 shows you the structure and the assignment of the instance DB for the Frequency Meter integrated function.

Table 3-10 Instance DB of SFB 30

Operand	Symbol	Meaning
DBD 0	PRES_U_LIMIT	Upper limit comparison value (new)
DBD 4	PRES_L_LIMIT	Lower limit comparison value (new)
DBX 8.0	SET_U_LIMIT	Set upper limit comparison value
DBX 8.1	SET_L_LIMIT	Set lower limit comparison value
DBD 10	FREQ	Frequency
DBD 14	U_LIMIT	Upper limit comparison value (current)
DBD 18	L_LIMIT	Lower limit comparison value (current)
DBX 22.0	STATUS_U	Upper limit status bit
DBX 22.1	STATUS_L	Lower limit status bit

Length of the Instance DB

The data for the Frequency Meter integrated function are 24 bytes in length and begin at address 0 in the instance DB.

3.8 Evaluation of Process Interrupts

Introduction

The Frequency Meter integrated function triggers process interrupts on the occurrence of certain events; provided you have configured a sample time of 1 ms, 2 ms or 4 ms with *STEP 7* and have activated the process interrupts.

Configurable Events

The events which can result in a process interrupt are listed in Table 3-11 together with the parameters you must assign in *STEP 7*.

Table 3-11 Events which can Cause a Process Interrupt

Process Interrupt on	Description	Configuration
Actual value falling below comparison value lower limit	A process interrupt is triggered if the actual value falls below the comparison value lower limit	Falls below comparison value lower limit: process interrupt activated
Actual value exceeding comparison value upper limit	A process interrupt is triggered if the actual value exceeds the comparison value upper limit	Exceeds comparison value upper limit: process interrupt activated

Process Interrupt OB

When a process interrupt occurs, the process interrupt OB (OB 40) is called up. The event which has invoked OB 40 is stored in the start information (declaration section) of the OB 40.

Start Information of OB 40 for Integrated Function

Table 3-12 shows the relevant temporary (TEMP) variables of OB 40 for the Frequency Meter Integrated Function of the CPU 312 IFM/314 IFM. You will find a description of OB 40 in the *System and Standard Functions* Reference Manual.

Table 3-12 Start Information of OB 40 for Frequency Meter Integrated Function

Variable	Data Type	Description	
OB40_MDL_ADDR	WORD	B#16#7C	Display in local data word 6: • Address of module which triggered interrupt (in this case the CPU)
OB40_POINT_ADDR	DWORD	see Figure 3-6	Display in local data double word 8: • Integrated function which triggered interrupt • Event which triggered interrupt

Display of the Event which Triggered the Interrupt

From the variable OB40_POINT_ADDR you can read which Integrated Function triggered the interrupt and which event led to the triggering of the interrupt. The figure below shows the assignment to the bits of local data doubleword 8.

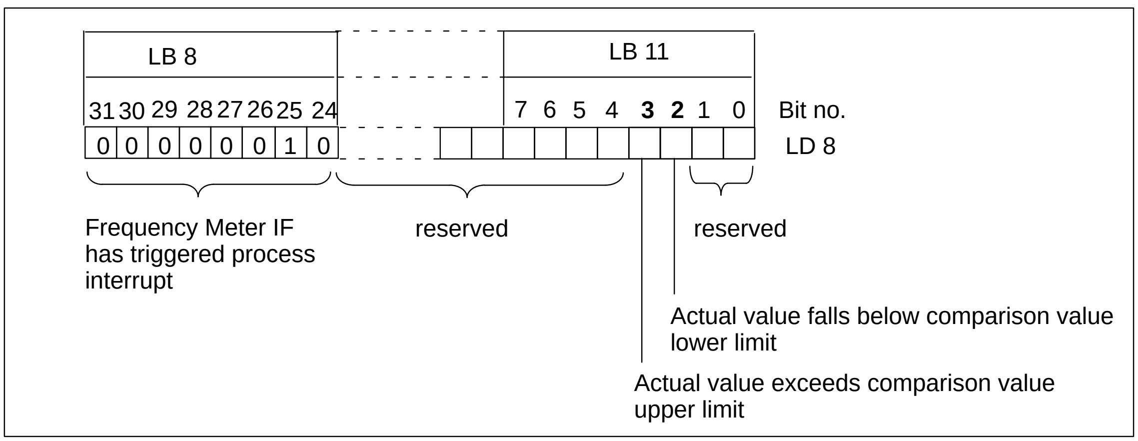

Figure 3-6 Start Information of OB 40: Which Event Triggered Interrupt (Frequency Meter)?

Evaluation in User Program

The evaluation of process interrupts in the user program is described in the Programming Manual *System Software for S7-300/400, Program Design*.

3.9 Calculating the Cycle Time

Introduction

The calculation of the cycle time for the CPUs is described in detail in the manual *S7-300 Programmable Controller, Installation and Hardware*. The following paragraphs describe the times which must be included in the calculation when the Frequency Meter integrated function is running.

Calculation

You can calculate the cycle time with the following formula:

Cycle time = $t_1 + t_2 + t_3 + t_4$

t_1 = Process image transfer time (process output image and process input image)[1]

t_2 = Operating system runtime including load generated by an executing integrated function[1]

t_3 = User program execution time[2] including the SFB runtime when an SFB call is made in the program cycle[3]

t_4 = Updating time of the instance DB at the cycle control point (if updating parameterized with STEP 7)

Runtime of SFB 30

The runtime of SFB 30 is typically 220 µs.

Instance DB Updating Time

The updating time of the instance DB at the cycle control point is 100 µs for the Frequency Meter integrated function.

Increased Cycle Time

Please note that the cycle time can be increased due to:

- Time-controlled execution
- Interrupt handling
- Diagnostics and error handling

Response Time

The following applies for the IF frequency meters: Response time = Process interrupt response time. The process interrupt response time is the period that elapses between violation of the current comparison value to the processing of the OB 40. With the parameterited measuring time of 1, 2 or 4 ms, the respone time is calculated as follow:

- Process interrupt response time when violating the upper comparison value < 1ms + measuring time
- Process interrupt response time when violating the lower comparison value > 1ms + measuring time + 1 / lower limit frequency

1 Please refer to the manual *S7-300 Programmable Controller, Installation and Hardware* for the time required for the CPU 312 IFM.

2 You have to determine the user program execution time, because it depends on your user program.

3 If the SFB is called several times in a program cycle, you should multiply the runtime of the SFB by the number of calls.

3.10 Example Applications

In this Section

In this section, you will find two example applications for the Frequency Meter integrated function. The first example contains a routine for monitoring the speed of a drive within a defined speed range.

The second example is an extension of the first. The user can change the speed range; two lamps are used to indicate which speed range is set.

Note

The CPU 312 IFM is used for the application examples. The examples can be implemented in the same way using the CPU 314 IFM provided you take account of the other integrated inputs/outputs (see Table 3-1).

In this Section

3.10.1 Speed Monitoring within a Fixed Speed Range

Task

A shaft rotates at an approximately constant speed. The speed of the drive is measured using a light barrier, and the Frequency Meter checks that the speed is within a defined range. If the permissible speed range is exceeded ($960 \leq n \leq 1080$ rpm), a reaction is triggered by the user program:

- Speed above permissible level: red lamp lights up
- Speed below permissible level: yellow lamp lights up

Wiring

The technology and wiring of the speed monitoring system are shown in Figure 3-7.

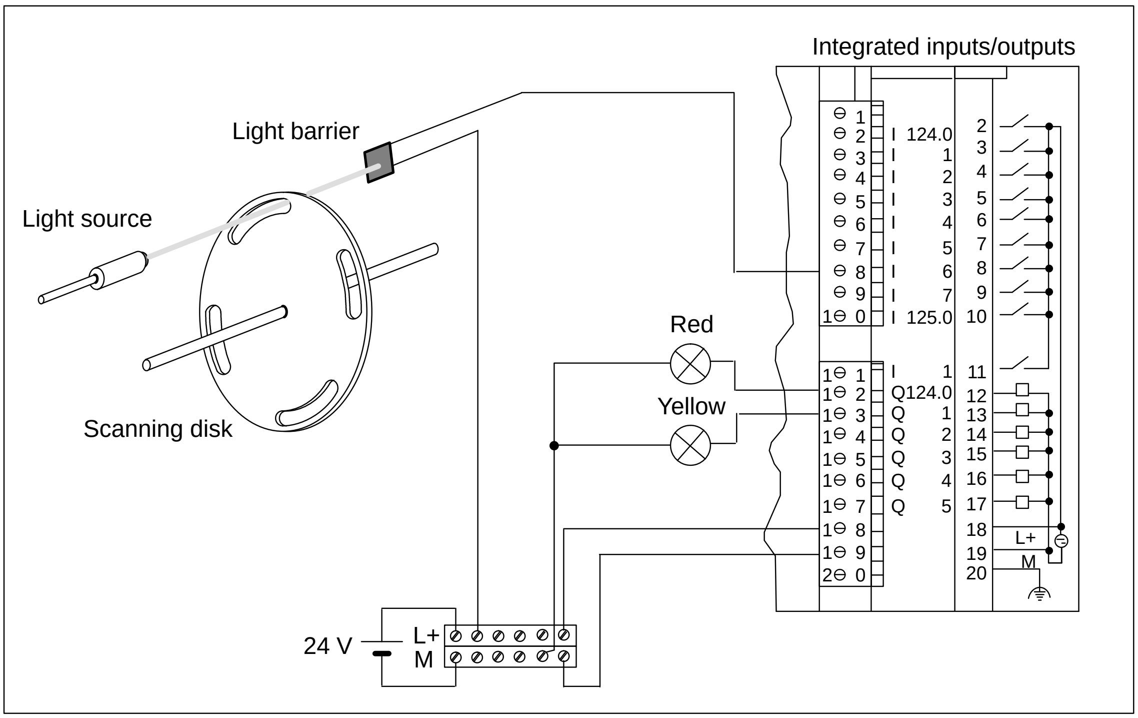

Figure 3-7 Speed Monitoring of a Shaft (1)

Design of the Scanning Disk

In Figure 3-7, the scanning disk has four elongated holes of equal length, positioned symmetrically on the disk. The actual frequency is therefore a quarter of the measured frequency.

Why Elongated Holes?

The light slots are measured by the light barrier and transmitted as a measured signal to the Meter digital input.

The measured signal is composed of 1 pulse time + 1 pulse interval. It is only detected reliably by the Frequency Meter if the pulse time ≥ 50 µs and the pulse interval ≥ 50 µs (see Appendix A).

As the current frequency approaches the frequency limit of 10 kHz, the following ratio must be maintained for the fulfilment of the above condition:

Pulse time : pulse interval = 1 : 1

In our example:

- 1 pulse time = 1 light slot
- 1 pulse interval = 1 area without a light slot

You therefore attain the optimum pulse time/pulse interval ratio through the symmetrical division of the light slots on the scanning disk. The following applies:

Length of a light slot = length of an area without a light slot

Function of the Inputs and Outputs

Table 3-13 lists the functions of the inputs and outputs for the example.

Table 3-13 Wiring of the Inputs and Outputs (1)

Terminal	Input/ Output	Function in Example
8	I 124.6	The positive edges of the signal are measured. 1 light slot on the scanning disk corresponds to 1 positive edge.
12	Q 124.0	The output is enabled when the upper limit comparison value is exceeded. The red lamp lights up when the speed is > 1080 rpm.
13	Q 124.1	The output is enabled when the value falls below the lower limit comparison value. The yellow lamp lights up when the speed is < 960 rpm. This is the case during start-up, for example, while the shaft drive has not yet reached its permissible speed.
18	L+	24 VDC supply voltage
19	M	Reference potential of the supply voltage

Sequence Diagram

The sequence diagram in Figure 3-8 illustrates the relationship between the speed and the digital outputs.

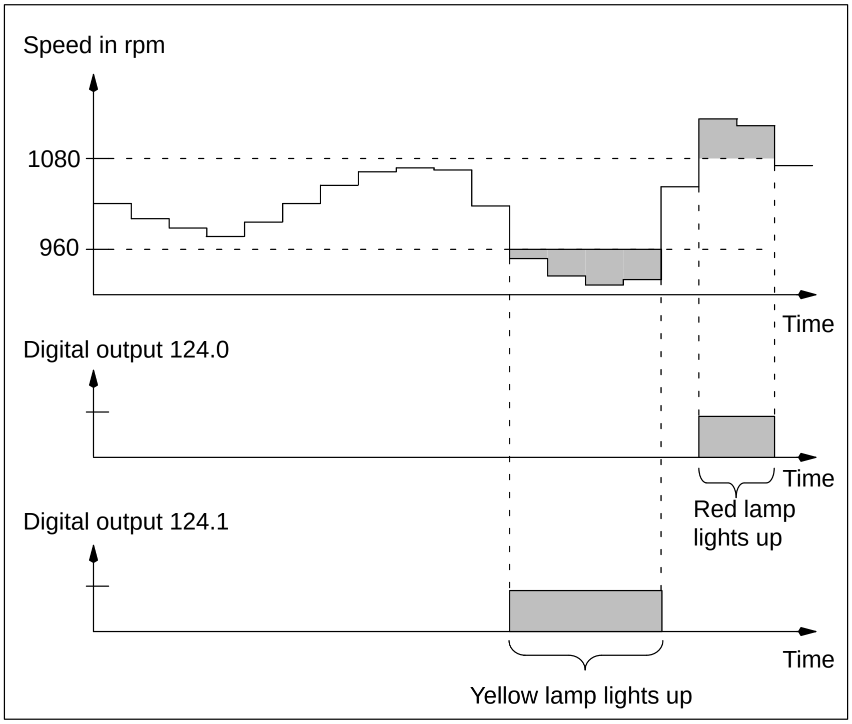

Figure 3-8 Sequence Diagram for Example 1

Parameter Assignment with *STEP 7*

You set the parameters for the CPU as follows with *STEP 7*:

Table 3-14 Parameters for the Frequency Meter Example

Parameter	Input	Description
No. of instance DB	62	Instance DB for the example (default value)
Sample time	4 s	Time interval in which the IF calculates the current frequency value
Automatic updating at the cycle control point[1]	Activated	The instance DB is updated at each cycle control point.

1 Only necessary with CPU 314 IFM input

Calculation of the Upper and Lower Limit Comparison Values

Table 3-15 illustrates the calculation of the comparison values for the example.

Further on in the example, you will find out how to pass the comparison values to SFB 30 from the user program.

Table 3-15 Determination of the Comparison Values

Comparison Value	**Speed**	**Frequency at a Configured Sample Time of 10 s**	**Upper/Lower Limit Comparison Value for SFB 30**
Upper limit	1080 rpm	$\frac{1080}{60} = 18\frac{1}{s} = 18\ \text{Hz}$	18 Hz × 4 (light slots) = 72 Hz Input parameter PRES_U_LIMIT for SFB 30 (in mHz): **72000**
Lower limit	960 rpm	$\frac{960}{60} = 16\frac{1}{s} = 16\ \text{Hz}$	16 Hz × 4 (light slots) = 64 Hz Input parameter PRES_L_LIMIT for SFB 30 (in mHz): **64000**

Initialization of SFB 30

SFB 30 is called at startup from OB 100 and initialized once. The comparison values are transferred to SFB 30 in MHz.

SFB 30 is illustrated in Figure 3-9 with the initialized input parameters.

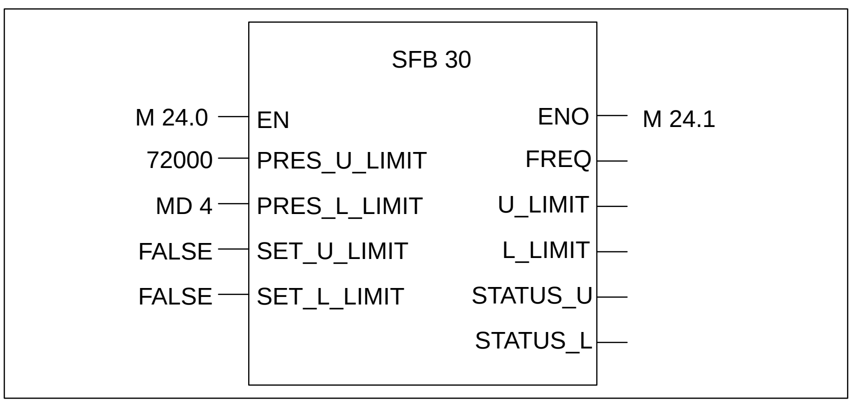

Figure 3-9 Initialization of SFB 30 at Start-Up (1)

Cyclic Calling of SFB 30

SFB 30 is called cyclically in OB 1. The assignment of SFB 30 is illustrated in Figure 3-10.

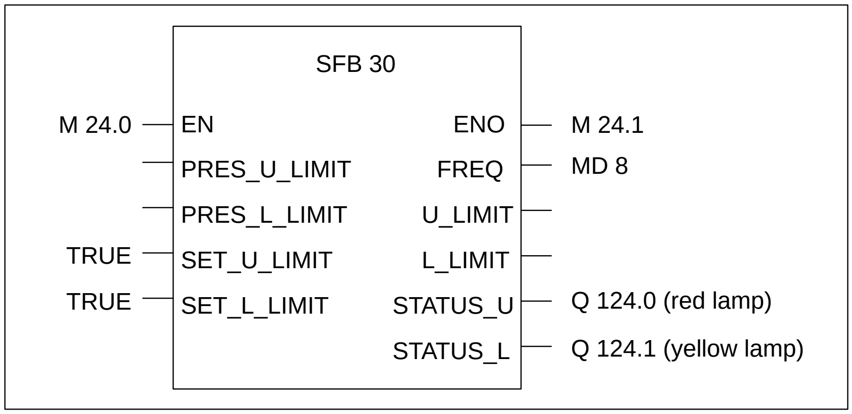

Figure 3-10Initialization of SFB 30 in the Cyclic Program (1)

Status Bits in the User Program

If the upper or lower limit of the speed range is exceeded, the corresponding status bit of SFB 30 is enabled.

When status bit STATUS_U (upper limit exceeded) is enabled, the red lamp is actuated with output 124.0.

When status bit STATUS_L (lower limit exceeded) is enabled, the yellow lamp is enabled with output 124.1.

As long as no valid frequency is available, the signal state of the status bits is 0.

Output Parameter FREQ

The output parameter FREQ outputs the actual measured frequency. You can evaluate the frequency in the user program. Because of the four light slots, you must divide the frequency by four to obtain the actual frequency and thus the speed of the shaft (implemented in the following user program).

Instance DB of SFB 30

In the example, the data are stored in instance DB 62.

User Program

In the following section, you will find the user program for the example. The program was created with the *Statement List Editor in STEP 7*.

Global Data Used

Table 3-16 shows the global data used in the user program.

Table 3-16 Global Data for Example 1

Global Data	Meaning
MD 4	Comparison value (new)
MD 8	Current measured frequency
MD 12	Actual shaft speed in 1/min
M 24.0	Enable SFB 30 execution
M 24.1	Store BR bit (= output parameter ENO of SFB 30)
A 124.0	Actuate red lamp
A 124.1	Actuate yellow lamp

OB 100 Statement Section

You enter the following statement list (STL) user program in the statement section of OB 100:

```
STL (OB 100)                                          Explanation
Network 1
       L                L#64000                       Define comparison value PRES_L_LIMIT in
       T                MD 4                          MD 4 (monitoring possible with STATUS
                                                      VAR)
       SET                                            Enable SFB 30 execution
       =                M 24.0
       A                M 24.0                        If M 24.0 = 1, i.e. EN = 1 at SFB 30,
                                                      SFB is executed;
       JNB              m01                           If RLO = 0, jump to m01

       CALL             SFB 30, DB 62                 Call SFB 30 with instance DB
        PRES_U_LIMIT:   = L#72000                     Define comparison value PRES_U_LIMIT
        PRES_L_LIMIT:   = MD 4                        Assign to MD 4
        SET_U_LIMIT:    = FALSE                       SET_U_LIMIT = 0, to generate pos. edge
                                                      in OB 1
        SET_L_LIMIT:    = FALSE                       SET_L_LIMIT = 0, to generate pos. edge
                                                      in OB 1
        FREQ:           =
        U_LIMIT:        =
        L_LIMIT:        =
        STATUS_U:       =
        STATUS_L:       =
m01:   A                BR                            Query BR bit (= ENO at SFB 30) for
                                                      error evaluation
       =                M 24.1
```

OB 1 Statement Section

You enter the following STL user program in the statement section of OB 1:

STL (OB 1)			Explanation
Network 1			
	.		Individual user program
	.		
	A	M 24.1	If M 24.1 = 1, i.e. EN = 1 at SFB 30, SFB is executed;
	JNB	m01	If RLO = 0, jump to m01
	CALL	SFB 30, DB 62	Call SFB 30 with instance DB
	PRES_U_LIMIT:	=	
	PRES_L_LIMIT:	=	
	SET_U_LIMIT:	= TRUE	Set comparison values with pos. edge
	SET_L_LIMIT:	= TRUE	Current measured frequency is stored in
	FREQ:	= MD 8	MD 8
	U_LIMIT:	=	
	L_LIMIT:	=	
	STATUS_U:	= A 124.0	If Q 124.0 = 1, red lamp lights up
	STATUS_L:	= A 124.1	If Q 124.1 = 1, yellow lamp lights up
m01:	A	BR	Query BR bit (= ENO at SFB 30) for er-
	=	M 24.1	ror evaluation
	L MD 8		End if valid speed value has not been read
	L L#-1		
	==D		
	BEC		
	L	MD 8	Convert measured frequency to actual
	L	4000	shaft speed
	/D		
	L	L#60	
	*D		
	T	MD 12	Speed is stored in MD 12 in decimal format in 1/min.

3.10.2 Speed Monitoring within Two Speed Ranges

Introduction

The following example is an extension of the example in Section 3.10.1. All functions which are identical in the two examples are therefore listed in Section 3.10.1. The following text contains references to the appropriate points in Section 3.10.1.

Task

A shaft rotates at an approximately constant speed. The speed of the drive can be set at two levels. It is measured by a light barrier and monitored by the Frequency Meter integrated function. The user can switch between the two speed ranges with a pushbutton switch. When the CPU is switched on, the speed range is set to setting 1.

Permissible speed range 1: $960 \leq n \leq 1080$ rpm

Permissible speed range 2: $1470 \leq n \leq 1520$ rpm

When the speed range is violated, a reaction is triggered by the user program:

- Speed above permissible range 1: red lamp 1 lights up
- Speed below permissible range 1: yellow lamp 1 lights up
- Speed above permissible range 2: red lamp 2 lights up
- Speed below permissible range 2: yellow lamp 2 lights up

Wiring

The technology and wiring of the speed monitoring system are shown in Figure 3-11.

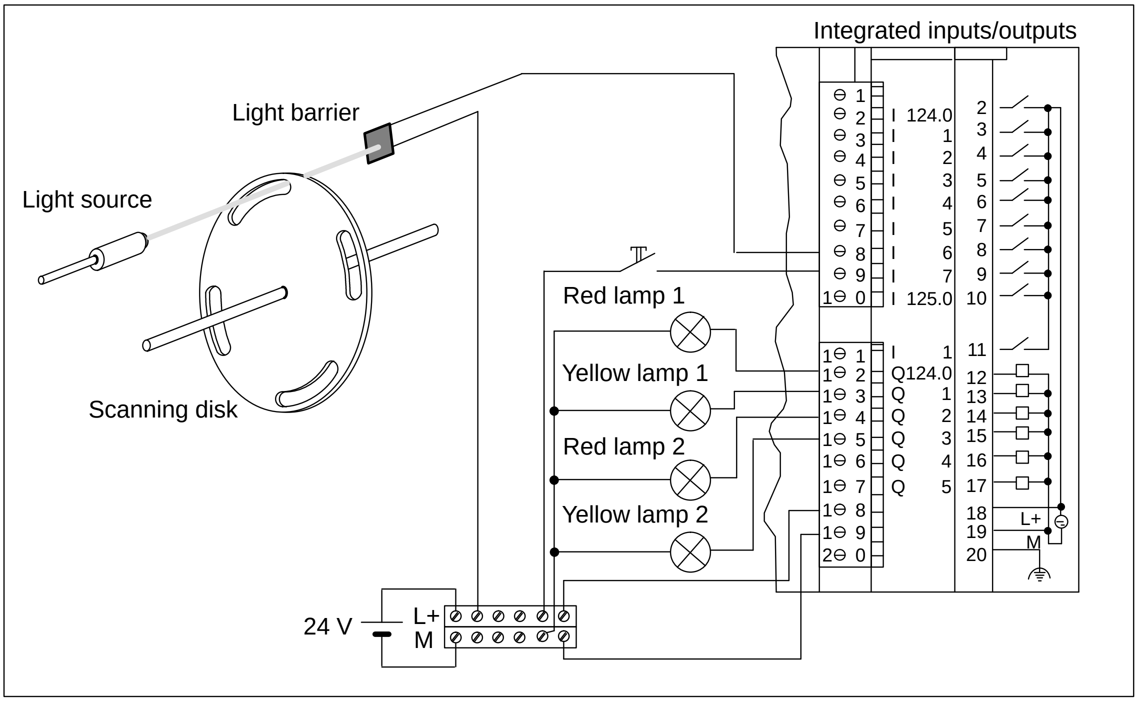

Figure 3-11 Speed Monitoring of a Shaft (2)

Function of the Inputs and Outputs

Table 3-17 lists the functions of the inputs and outputs for the example.

Table 3-17 Wiring of the Inputs and Outputs (2)

Terminal	Input/ Output	Function in Example
8	I 124.6	The positive edges of the signal are measured. 1 light slot on the scanning disk corresponds to 1 positive edge.
9	I 124.7	The permissible speed range is changed from 1 to 2, or vice-versa, by pressing the pushbutton.
12	Q 124.0	The output is enabled when the upper limit comparison value of speed range 1 is exceeded. Red lamp 1 lights up when the speed is > 1080 rpm.
13	Q 124.1	The output is enabled when the value falls below the lower limit comparison value of speed range 1. Yellow lamp 1 lights up when the speed is < 960 rpm.

Tabelle 3-17 Wiring of the Inputs and Outputs (2), Continued

Terminal	Input/ Output	Function in Example
14	Q 124.2	The output is enabled when the upper limit comparison value of speed range 2 is exceeded. Red lamp 2 lights up when the speed is > 1520 rpm.
15	Q 124.3	The output is enabled when the value falls below the lower limit comparison value of speed range 2. Yellow lamp 2 lights up when the speed is < 1470 rpm.
18	L+	24 VDC supply voltage
19	M	Reference potential of the supply voltage

Sequence Diagram for Speed Range 2

The sequence diagram in Figure 3-12 illustrates the relationship between speed range 2 and the associated digital outputs. You will find the sequence diagram for speed range 1 in Section 3.10.1.

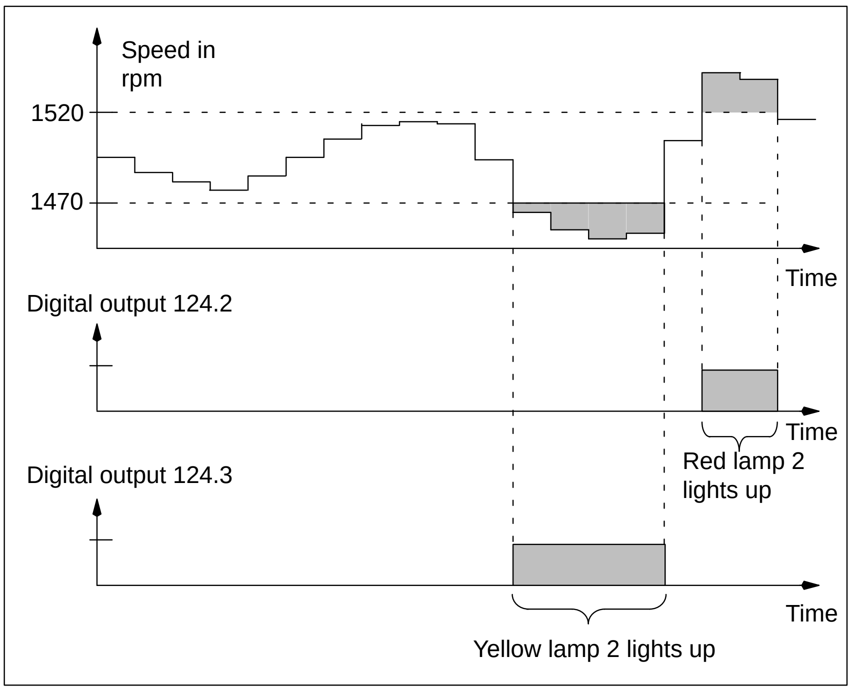

Figure 3-12 Sequence Diagram for Example 2

Parameter Assignment with *STEP 7*

You set the parameters for the CPU with *STEP 7* as listed in Section 3.10.1.

Calculation of the Upper and Lower Limit Comparison Values

Table 3-18 illustrates the calculation of the comparison values for speed range 2. You will find the calculation of the comparison values for speed range 1 in Section 3.10.1.

Further on in the example, you will find out how to pass the comparison values to SFB 30 from the user program.

Table 3-18 Determination of the Comparison Values for Speed Range 2

Comparison Value	Speed	Frequency at a Configured Sample Time of 10 s	Upper/Lower Limit Comparison Value for SFB 30
Upper limit	1520 rpm	$\frac{1520}{60} \approx 25.3\frac{1}{s} \approx 25.3$ Hz	25.3 Hz × 4 (light slots) ≈ 101 Hz Input parameter PRES_U_LIMIT for SFB 30 (in mHz): **101000**
Lower limit	1470 rpm	$\frac{1470}{60} = 24.5\frac{1}{s} = 24.5$ Hz	24.5 Hz × 4 (light slots) = 98 Hz Input parameter PRES_L_LIMIT for SFB 30 (in mHz): **98000**

Initialization of SFB 30

SFB 30 is called from OB 100 twice on start-up and initialized. The comparison values for speed range 1 are transferred to SFB 30 in MHz.

Figure 3-13 shows SFB 30 (2nd call in OB 100) with the initialized input parameters.

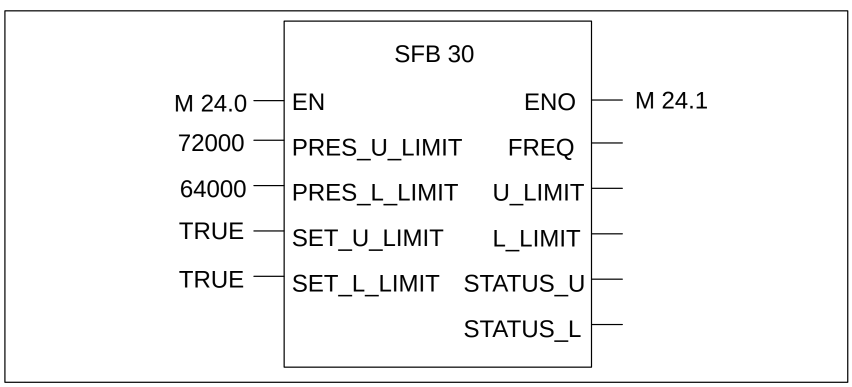

Figure 3-13 Initialization of SFB 30 on Start-Up (2)

Cyclic Calling of SFB 30

SFB 30 is called cyclically in OB 1. The new comparison values can be passed to SFB 30 in mHz.

Figure 3-14 shows SFB 30 with the input and output parameters.

Pressing of the momentary-contact switch (I 124.7) generates edges at the input parameters SET_U_LIMIT and SET_L_LIMIT. As soon as the edges occur, the comparison values for speed range 2, for example, are accepted by the SFB 30.

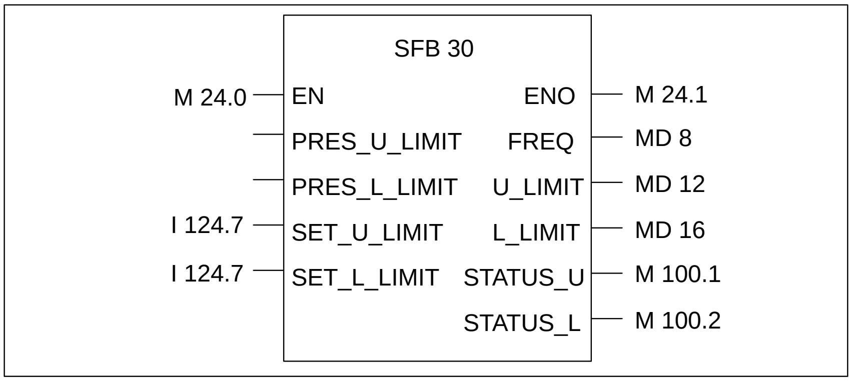

Figure 3-14 Initialization of SFB 30 in the Cyclic Program (2)

Switching to Speed Range 1

When the pushbutton (I 124.7) is pressed again, the comparison values for speed range 1 are accepted by SFB 30.

Status Bits in the User Program

If the upper or lower limit of the speed range is exceeded, the corresponding status bit of SFB 30 is enabled.

Speed range 1:

- When status bit STATUS_U (upper limit exceeded) is enabled, red lamp 1 is actuated with output 124.0.
- When status bit STATUS_L (lower limit exceeded) is enabled, yellow lamp 1 is enabled with output 124.1.

Speed range 2:

- When status bit STATUS_U (upper limit exceeded) is enabled, red lamp 2 is actuated with output 124.2.
- When status bit STATUS_L (lower limit exceeded) is enabled, yellow lamp 2 is enabled with output 124.3.

As long as no valid frequency is available, the signal state of the status bits is 0.

Output Parameter FREQ

The output parameter FREQ outputs the actual measured frequency. You can evaluate the frequency in the user program. Because of the four light slots, you must divide the frequency by four to obtain the actual frequency and thus the speed of the shaft (implemented in the following user program).

Instance DB of SFB 30

In the example, the data are stored in instance DB 62.

User Program

In the following section you will find the user program for the example. The program was created with the *Statement List Editor in STEP 7*.

Global Data Used

Table 3-19 shows the global data used in the user program.

Table 3-19 Global Data for Example 2

Global Data	Meaning
MD 8	Current measured frequency
MD 20	Actual shaft speed in 1/min
MD 12	Current comparison value upper limit
MD 16	Current comparison value lower limit
M 24.0	Enable SFB 30 execution
M 24.1	Store BR bit (= output parameter ENO of SFB 30)
M 99.0	Auxiliary memory bit
M 99.1	Edge memory bit
M 100.0 = 1	Speed range 1
M 100.0 = 0	Speed range 2
M 100.1	STATUS_U
M 100.2	STATUS_L
Q 124.0	Actuate red lamp 1
Q 124.1	Actuate red lamp 2
Q 124.2	Actuate yellow lamp 1
Q 124.3	Actuate yellow lamp 2
I 124.7	Pushbutton for switchover of speed range

OB 1 Statement Section

You enter the following STL user program in the statement section of OB 1:

STL (OB 100)	Explanation
Network 1	
CALL SFB 30 , DB62	
PRES_U_LIMIT:=	
PRES_L_LIMIT:=	
SET_U_LIMIT :=FALSE	SET_U_LIMIT = 0, to generate pos. edge at 2nd call of SFB 30
SET_L_LIMIT :=FALSE	SET_L_LIMIT = 0, to generate pos. edge at 2nd call of SFB 30
FREQ :=	
U_LIMIT :=	
L_LIMIT :=	
STATUS_U :=	
STATUS_L :=	
CALL SFB 30 , DB62	
PRES_U_LIMIT:=L#72000	Specify comparison values for speed range 1
PRES_L_LIMIT:=L#64000	
SET_U_LIMIT :=TRUE	
SET_L_LIMIT :=TRUE	
FREQ :=	
U_LIMIT :=	
L_LIMIT :=	
STATUS_U :=	
STATUS_L :=	
A BR	
= M 24.0	If no error has occurred, then SFB enable for OB1
SET	
= M 100.0	Preset speed range 1

OB 1 Statement Section

You enter the following STL user program in the statement section of OB 1:

```
STL (OB 1)                                   Explanation
Network 1

       A     I    124.7                      Edge generation for pushbutton input
       FP    M     99.0                      for changing speed range
       =     M     99.1
       A     M     99.1
       JBN   JCN
       AN    M    100.0                      Invert speed range marker
       =     M    100.0                      if positive edge at I 124.7 (M 100.0 = 1 ⇒
JCN:   A     M    100.0                      speed range 1)
       JC   DZB1                             If speed range 1, then jump to DZB1.
       L     L#101000                        Specify comparison value PRES_U_LIMIT for
       T     DB62.DBD    0                   speed range 2 direct in the instance DB.
       L     L#98000                         Specify comparison value PRES_L_LIMIT for
       T     DB62.DBD    4                   speed range 2 direct in the instance DB.
       JU   wei
DZB1:  L     L#72000                         Specify comparison value PRES_U_LIMIT for
       T     DB62.DBD    0                   speed range 1 direct in the instance DB.
       L     L#64000                         Specify comparison value PRES_L_LIMIT for
       T     DB62.DBD    4                   speed range 1 direct in the instance DB.
wei:   NOP   0
       A     M     24.0                      Enable from OB 100
       JBNB M001
       CALL  SFB   30 , DB 62
        PRES_U_LIMIT:=
        PRES_L_LIMIT:=
        SET_U_LIMIT :=E124.7                 Transfer of comparison value specifications if
        SET_L_LIMIT :=E124.7                 momentary-contact switch I 124.7 has been pressed
        FREQ        :=MD8                    Current frequency
        U_LIMIT     :=MD12                   Current comparison value U_LIMIT
        L_LIMIT     :=MD16                   Current comparison value L_LIMIT
        STATUS_U    :=M100.1                 Indicator: Upper limit exceeded
        STATUS_L    :=M100.2                 Indicator: Lower limit exceeded
```

STL (OB 1, Continued)	Explanation
M001: A BR	
= M 24.1	Indicates whether SFB call correctly executed
A M 100.0	If speed range 1
A M 100.1	and upper limit exceeded,
= Q 124.0	then red lamp 1 on
A M 100.0	If speed range 1
A M 100.2	and lower limit exceeded,
= Q 124.1	then yellow lamp 1 on
AN M 100.0	If speed range 2
A M 100.1	and upper limit exceeded,
= Q 124.2	then red lamp 2 on
AN M 100.0	If speed range 2
A M 100.2	and lower limit exceeded,
= Q 124.3	then yellow lamp 2 on
L MD 8	End if valid speed value not yet read
L L#-1	
==D	
BEC	
L MD 8	Convert indicated frequency to current speed
L 4000	
/D	
L 60	
*D	Indicate speed [1/min.]
T MD 20	

Counter Integrated Function

4

Integrated Inputs/Outputs

Table 4-1 lists the special integrated inputs/outputs of the CPU 312 IFM and CPU 314 IFM for the Counter integrated function.

Table 4-1 Overview: Integrated Inputs/Outputs for Counter Integrated Function on CPU 312 IFM and CPU 314 IFM

CPU 312 IFM	CPU 314 IFM	Function
I 124.6	I 126.0	Digital input up
I 124.7	I 126.1	Digital input down
I 125.0	I 126.2	Digital input direction
I 125.1	I 126.3	Digital input hardware start/stop
Q 124.0	Q 124.0	Digital output A
Q 124.1	Q 124.1	Digital output B

Note

The CPU 312 IFM is used for examples in this chapter. The examples can be implemented in the same way using the CPU 314 IFM provided you take account of the other integrated input/outputs (see Table 4-1).

In this Chapter

4.1 Function Overview

Introduction

In this section, you will find an overview diagram (block diagram) for the Counter integrated function. The block diagram contains the main components of the integrated function and all its inputs and outputs.

Sections 4.2 and 4.3 refer to the block diagram. These sections describe the interaction of the main components of the Counter integrated function and their inputs and outputs.

Purpose of the Integrated Function

The Counter integrated function enables the measurement of counting pulses up to a frequency of 10 kHz. The Counter integrated function can count up and down.

Block Diagram

Figure 4-1 shows the block diagram for the Counter integrated function.

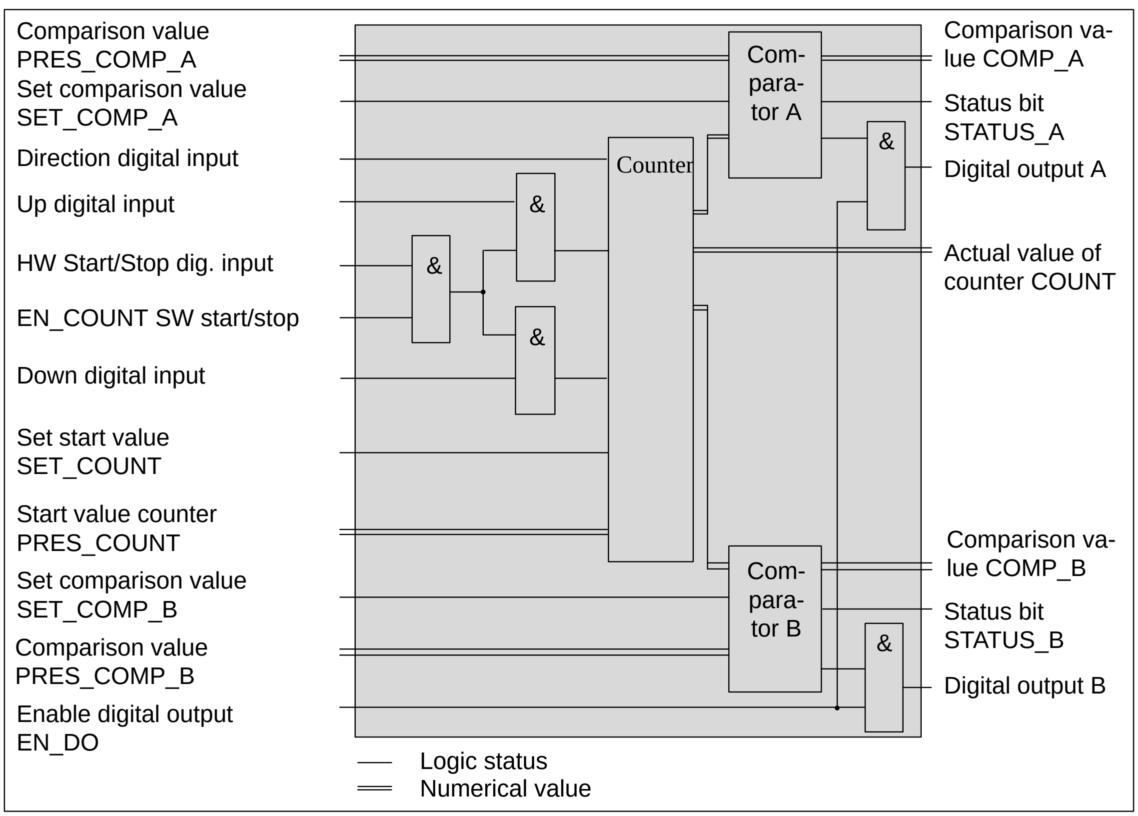

Figure 4-1 Block Diagram for Counter Integrated Function

4.2 How the Counter Operates

Counter

The counter calculates the actual value of the counter from the counting pulses (up and down).

The counting pulses are measured via two digital inputs on the CPU: Up digital input and Down digital input.

You use *STEP 7* to configure whether the digital inputs are evaluated and, if so, whether positive or negative edges are evaluated.

Actual Value of the Counter

The counter calculates the actual value according to the following formula:

Actual value = no. of edges on Up DI – no. of edges on Down DI

Function of the Counter

Figure 4-2 shows an example to illustrate how the actual value of the counter is changed by the counting pulses at the two digital inputs. The positive edges are evaluated on the Up digital input and the negative edges are evaluated on the Down digital input.

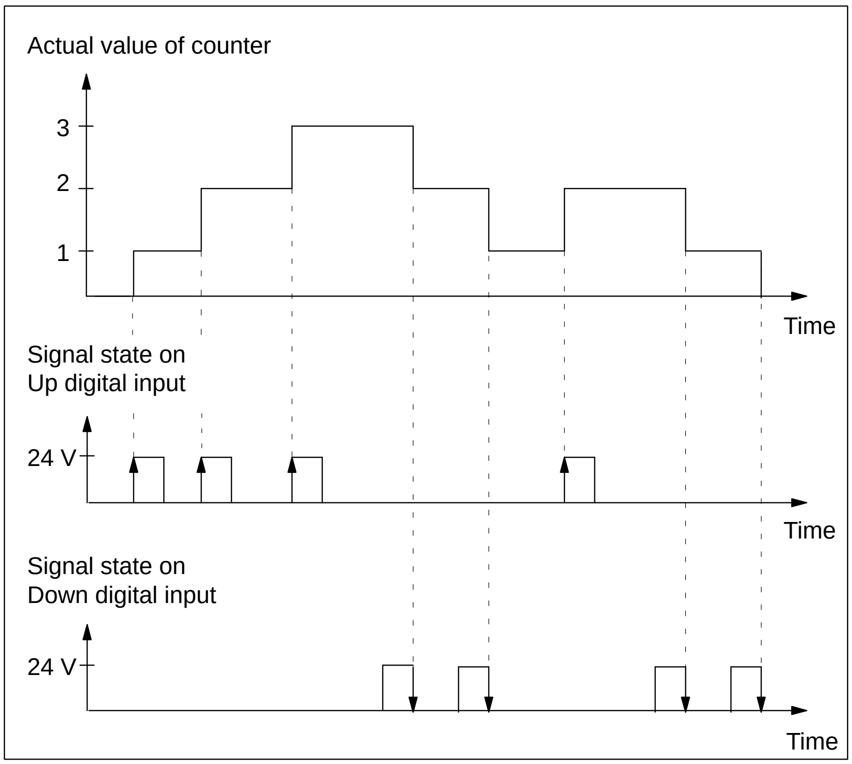

Figure 4-2 Counting Pulses and Actual Value of the Counter

Start/Stop Counter

You can start or stop the Counter integrated function in one of the following ways:

- From the integrated inputs/outputs: HW_Start/Stop digital input
- From the user program: input parameter EN_COUNT at SFB 29

The digital input and the input parameter are ANDed. This means that the Up and Down digital inputs are only evaluated when both are enabled.

Define Start Value for Counter

You can define the start value at which the counter begins counting with input parameter PRES_COUNT at SFB 29. The start value is accepted by the counter:

- On a positive edge on input parameter SET_COUNT of SFB 29
- On the occurrence of a counter event, for example, comparison value of the counter reached from below (parameterized with *STEP 7*).

Change Counting Direction

You can change the counting direction of the Up and Down digital inputs with the Direction digital input. While the signal status of the Direction digital input is 0, the Up digital input counts down **and** the Down digital input counts up.

Frequency Limit Exceeded

The Counter integrated function counts pulses up to a frequency of 10 kHz.

Warning

If the current frequency exceeds the frequency limit of 10 kHz:

- Correct operation of the integrated function is no longer assured
- The cycle load is increased
- The process interrupt response time is increased
- Communication errors can arise (up to termination of the connection)

When the cycle time watchdog responds, the CPU switches to STOP.

4.3 Function of a Comparator

Comparator

The Counter integrated function has two integrated comparators. A comparator compares the actual value of the counter with a defined comparison value and triggers a reaction on the occurrence of a configured event.

Response of the Comparator to Events

You can configure events for any comparator.

Events to which comparator A reacts:

- The actual value of the counter reaches the comparison value from below, that is the actual value changes from COMP_A-1 (COMP_A minus 1) to COMP_A.
- The actual value of the counter falls below the comparison value, that is the actual value changes from COMP_A to COMP_A-1.

Events to which comparator B reacts:

Comparator B reacts to the same events as comparator A. The only difference is that another comparison value (COMP_B) is assigned to comparator B.

Example

Figure 4-3 shows an example of all possible events to which the comparators can react. The following values are defined:

- Comparison value COMP_A = 350
- Comparison value COMP_B = 100

If the actual value of the counter changes from 349 to 350 or from 350 to 349 due to a counting pulse, a reaction is triggered by comparator A.

If the actual value of the counter changes from 99 to 100 or from 100 to 99 due to a counting pulse, a reaction is triggered by comparator B.

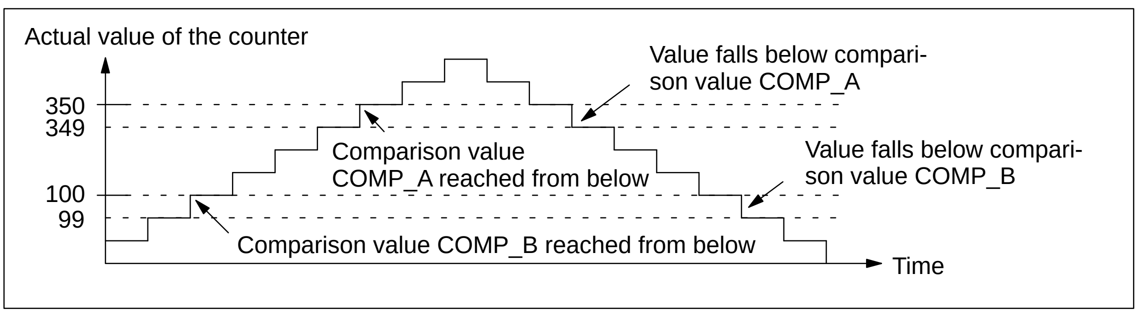

Figure 4-3 Events to which a Comparator Reacts

Configurable Reactions

The following reactions can be triggered when the actual value reaches or falls below the comparison value:

- Set/reset digital output A or B
- Trigger a process interrupt
- Reset the counter
- Set comparator A or B

You configure the reactions with STEP 7.

You will find an overview of the possible parameters and their value ranges in Section 4.4.

Configure Digital Outputs

You can configure the following properties for digital outputs A and B with *STEP 7*:

- On: the digital output is set
- Off: the digital output is reset
- Unaffected: the state of the digital output remains the same

Enable Digital Outputs

Input parameter EN_DO at SFB 29 is used to enable the digital outputs for the integrated function. Following the enable, the reactions of comparators A and B are transmitted directly to the automation process via the integrated inputs/outputs.

If input parameter EN_DO is continuously set to “0”, you can use the digital outputs as standard digital outputs.

Behavior of the Status Bits

Status bit STATUS_A or STATUS_B is set at SFB 29 if:

The actual value of the counter COUNT ≥ comparison value COMP_A (B)

You can evaluate the status bits in your user program.

Example

In Figure 4-4 you can see the reactions of digital output A and status bit STATUS_A when the actual value reaches and falls below comparison value COMP_A. The following parameters were assigned with *STEP 7*:

- Comparison value reached from below: Digital output A = on
- Value falls below comparison value: Digital output A = unchanged

You can reset the outputs used by the integrated function from the user program, for example, in order to reset digital output A.

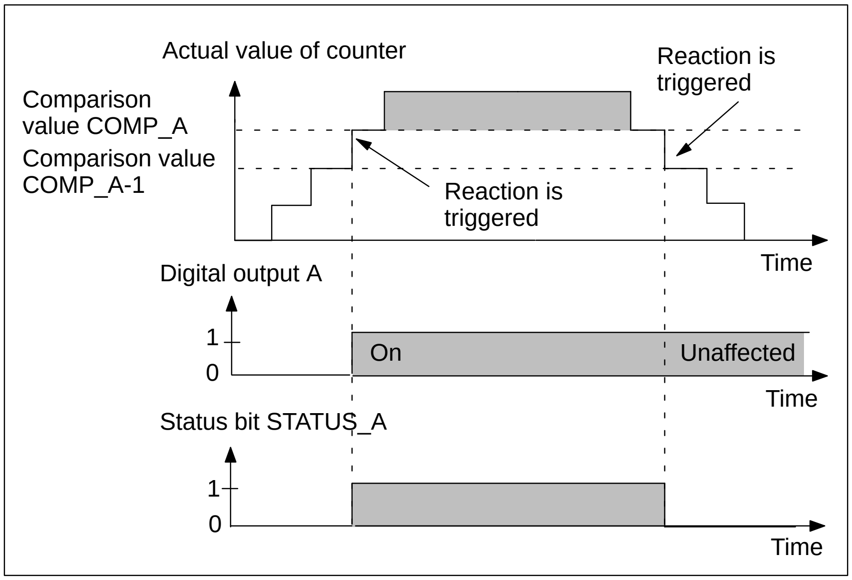

Figure 4-4 Example: Trigger Reactions

Define New Comparison Values

You can define new comparison values with input parameters PRES_COMP_A and PRES_COMP_B at SFB 29.

The new comparison values are accepted by the comparator:

- On a positive edge on the input parameters SET_COMP_A or SET_COMP_B at SFB 29
- On a counter event[1] with parameterized response.

[1] Counter event means the actual value of the counter reaches or exits a comparison value and the relevant response has been parameterized with *STEP 7*.

4.4 Assigning Parameters

Parameter Assignment with *STEP 7*

You assign the parameters for the integrated function with *STEP 7*. How to work with STEP 7 is described in the manual *Standard Software for S7 and M7, STEP 7*.

Parameters and their Value Ranges

Table 4-2 lists the parameters for the Counter integrated function.

Table 4-2 "Integrated Inputs/Outputs" Parameter Block

Parameter	Description	Value Range	Default Setting
Counter input: Up	You can set positive or negative edge evaluation on the Up digital input. If you select "deactivated", no counting pulses are evaluated. You can then use the associated digital input as a standard digital input.	Deactivated Positive edge Negative edge	Positive edge
Counter input: Down	You can set positive or negative edge evaluation on the Down digital input. If you select "deactivated", no counting pulses are evaluated. You can then use the associated digital input as a standard digital input.		Positive edge
Number of the instance DB	The instance DB contains the data exchanged between the integrated function and the user program.	1 to 63 CPU 314 IFM: 1 to 127	63
Automatic updating at the cycle control point[1]	You determine whether the instance DBs of the integrated function are to be updated at the cycle control point.	Activated/ deactivated	Activated
Comparison value reached from below (from COMP_A-1 to COMP_A)			
Digital output A	You can set the reaction of digital output A when the actual value reaches the comparison value from below.	Unaffected On Off	Unaffected
Process interrupt	You can specify that a process interrupt is to be triggered when the actual value reaches the comparison value from below.	Activated/ Deactivated	Deactivated
Reset counter	You can specify that the counter is reset when the actual value reaches the comparison value from below.	Activated/ Deactivated	Deactivated
Set comparator A	You can specify that comparator A is set when the actual value reaches the comparison value from below.	Activated/ Deactivated	Deactivated

1 Parameter can only be set in CPU 314 IFM. In the CPU 312 IFM, the parameter is automatically activated

Table 4-2 “Integrated Inputs/Outputs” Parameter Block, Continued

Parameter	Description	Value Range	Default Setting
Value falls below comparison value (from COMP_A to COMP_A-1)			
Digital output A	You can specify the reaction of digital output A when the actual value falls below the comparison value.	Unaffected On Off	Unaffected
Process interrupt	You can specify that a process interrupt is triggered when the actual value falls below the comparison value.	Activated/ Deactivated	Deactivated
Reset counter	You can specify that the counter is reset when the actual value falls below the comparison value.	Activated/ Deactivated	Deactivated
Set comparator A	You can specify that comparator A is set when the actual value falls below the comparison value.	Activated/ Deactivated	Deactivated
Comparison value reached from below (from COMP_B-1 to COMP_B) (see comparison value from COMP_A-1 to COMP_A)			
Value falls below comparison value (from COMP_B to COMP_B-1) (see comparison value from COMP_A to COMP_A-1)			

4.5 Wiring

In this Section

4.5.1 Connecting Sensors to the Integrated Inputs/Outputs

Introduction

The CPU 312 IFM is used as a wiring example. The example can be implemented in the same way with the CPU 314 IFM using other integrated inputs/outputs (see Table 4-1).

Function of the Digital Inputs

The sensors are connected to the Up and Down digital inputs.

The Counter integrated function can be started and stopped via the Hardware Start/Stop digital input.

The up/down counting direction on the digital inputs can be changed with the Direction digital input.

Hardware Start/ Stop Digital Input

The Hardware Start/Stop digital input is ANDed with input parameter EN_COUNT of SFB 29 (see Section 4.6).

If you do not connect any switch to the Hardware Start/Stop digital input, you must supply a permanent voltage of 24 V to the digital input. Only then are the counting pulses evaluated on the Up/Down digital inputs. You start/stop the counter with input parameter EN_COUNT of SFB 29.

Change Counting Direction

When you apply a voltage of 24 V to the Direction digital input, the counting direction on the Up/Down digital inputs is reversed.

Precondition: signal states of Hardware Start/Stop digital input and input parameter EN_COUNT of SFB 29 are 1.

Table 4-3 illustrates the function of the Direction digital input.

Table 4-3 Function of the Direction Digital Input

Direction Digital Input	Counting Direction
24 V applied	• Up digital input counts up and • Down digital input counts down
24 V not applied	• Up digital input counts down and • Down digital input counts up

Time Limits

When you set and reset the Hardware Start/Stop or Direction digital inputs, you must observe the following time limits:

- Before the first active edge of the counting pulse: time ≥ 100 μs
- After the last active edge of the counting pulse: time ≥ 100 μs

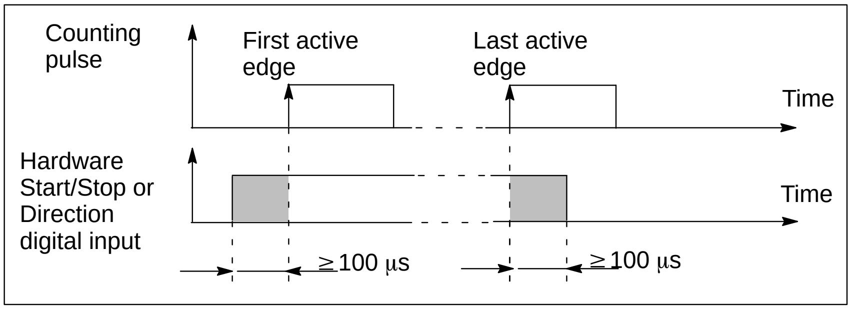

Figure 4-5 Timing of the Hardware Start/Stop and Direction Digital Inputs

Terminals

The terminals of the integrated inputs/outputs on the CPU 312 IFM for the Counter integrated function are listed in Table 4-4.

Table 4-4 Terminals for the Sensors

Terminal	Identifier	Description
8	I 124.6	Up
9	I 124.7	Down
10	I 125.0	Direction
11	I 125.1	Hardware Start/Stop
18	L+	Supply voltage
19	M	Ground

Terminal Connection Model

Figure 4-6 illustrates the connection of the sensors (for example, BERO proximity switches 1 and 2) to the integrated inputs/outputs.

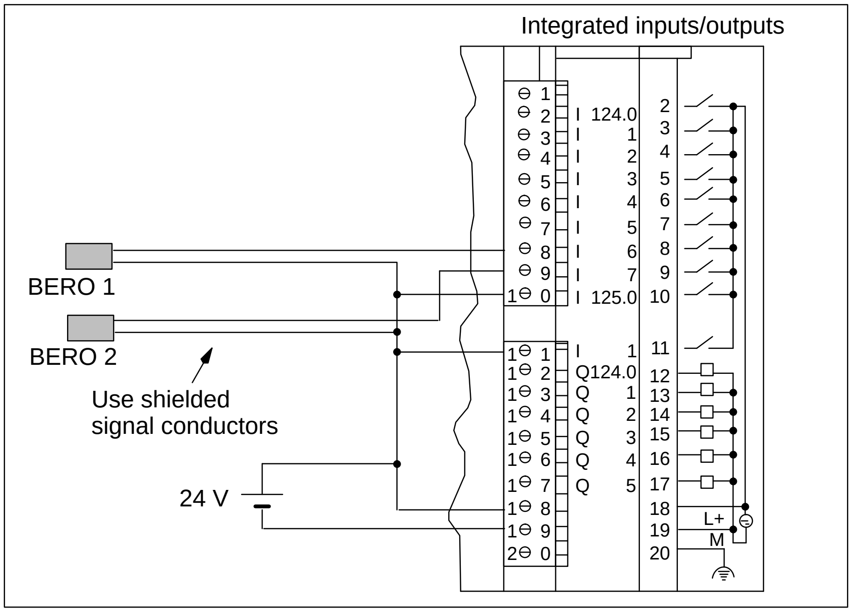

Figure 4-6 Sensor Wiring

Shielding

You must use shielded signal conductors to connect the sensors and you must connect the conductor shields to ground. Use the shield connecting element for this purpose.

You will find more detailed information on the installation of the conductor shield in the manual *S7-300 Programmable Controller, Installation and Hardware*.

4.5.2 Connecting Actuators to the Integrated Inputs/Outputs

Introduction

The CPU 312 IFM is used as a wiring example. The example can be implemented in the same way with the CPU 314 IFM using other integrated inputs/outputs (see Table 4-1).

Function of the Digital Outputs

Digital outputs A and B are available for connecting actuators to the integrated inputs/outputs.

Enable Digital Outputs

Before digital outputs A and B can perform their function, they must be enabled for the Counter integrated function. This is achieved by calling SFB 29 (input parameter EN_DO = 1) in the user program (see Section 4.6).

Following the enable, the reactions of comparators A and B are transmitted directly to the automation process via the integrated inputs/outputs.

If input parameter EN_DO is not enabled (EN_DO = 0), the Counter integrated function has no effect on digital outputs A and B. You can use digital outputs A and B as standard digital outputs.

Terminals

Table 4-5 shows the relevant terminals.

Table 4-5 Terminals for the Actuators

Terminal	Identifier	Description
12	Q 124.0	Digital output A
13	Q 124.1	Digital output B
18	L+	Supply voltage
19	M	Ground

Terminal Connection Diagram

Figure 4-7 shows an example for wiring digital outputs A and B.

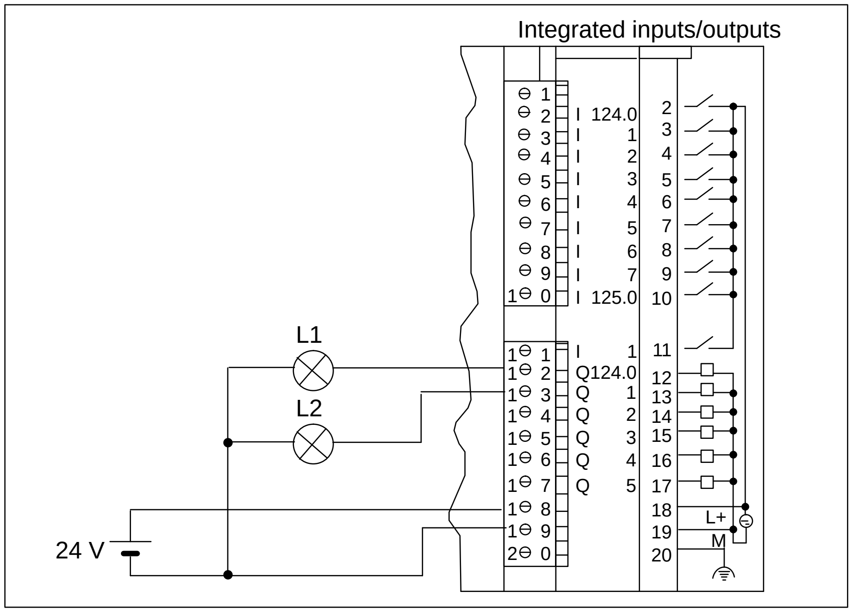

Figure 4-7 Actuator Wiring

4.6 System Function Block 29

Introduction

The Counter integrated function is assigned to SFB 29. A graphical illustration of SFB 29 is shown in Figure 4-8.

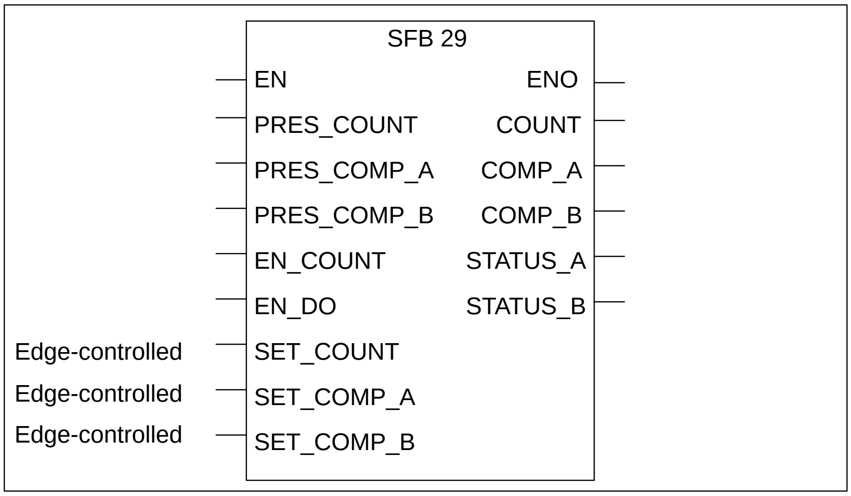

Figure 4-8 Graphical Illustration of SFB 29

Input Parameters of SFB 29

In Table 4-6 you will find a description of the input parameters of SFB 29.

Table 4-6 Input Parameters of SFB 29

Input Parameter	Description
EN	EN is the input parameter for enabling SFB 29. This input parameter causes the SFB to be executed. The input parameter has no effect on the execution of the integrated function. The SFB is executed as long as EN = 1. When EN = 0, the SFB is not executed. Data type: BOOL · Address ID: I, Q, M, L, D · Value range: 0/1 (FALSE/TRUE)
PRES_COUNT	You can use this input parameter to store a new start value for the counter. It is accepted following a positive edge on the SET_COUNT input parameter or on a counting event[1]. Data type: DINT · Address ID: I, Q, M, L, D · Value range: from -2147483648 to 2147483647
PRES_COMP_A	You can use this input parameter to store a new COMP_A comparison value. It is accepted following a positive edge on input parameter SET_COMP_A or on a counting event[1]. Data type: DINT · Address ID: I, Q, M, L, D · Value range: from -2147483648 to 2147483647
PRES_COMP_B	You can use this input parameter to store a new COMP_B comparison value. It is accepted following a positive edge on input parameter SET_COMP_B or on a counting event[1]. Data type: DINT · Address ID: I, Q, M, L, D · Value range: from -2147483648 to 2147483647
EN_COUNT	You activate the counter with input parameter EN_COUNT. With this parameter you enable the counter from the user program. Input parameter EN_COUNT is ANDed with the Hardware Start/Stop digital input. That means that the Up and Down digital inputs are only evaluated by the integrated function when both of the input parameters are enabled. Data type: BOOL · Address ID: I, Q, M, L, D · Value range: 0/1 (FALSE/TRUE)
EN_DO	When EN_DO = 1, the digital outputs are enabled for the Counter integrated function. Data type: BOOL · Address ID: I, Q, M, L, D · Value range: 0/1 (FALSE/TRUE)
SET_COUNT	Following a positive edge on this input parameter, the start value PRES_COUNT is accepted. Data type: BOOL · Address ID: I, Q, M, L, D · Value range: 0/1 (FALSE/TRUE)
SET_COMP_A	Following a positive edge on this input parameter, comparison value PRES_COMP_A is accepted. Data type: BOOL · Address ID: I, Q, M, L, D · Value range: 0/1 (FALSE/TRUE)
SET_COMP_B	Following a positive edge on this input parameter, comparison value PRES_COMP_B is accepted. Data type: BOOL · Address ID: I, Q, M, L, D · Value range: 0/1 (FALSE/TRUE)

1 Counting event means that the actual value of the counter reaches or falls below a comparison value and the corresponding reaction is configured with *STEP 7*.

Output Parameters of SFB 29

In Table 4-7 you will find a description of the output parameters of SFB 29.

Table 4-7 Output Parameters of SFB 29

Output Parameter	Description
ENO	Output parameter ENO indicates whether an error occurred during execution of SFB 29. If ENO = 1, no error occurred. If ENO = 0, SFB 29 was not executed or an error occurred during execution. Data type: BOOL Address ID: I, Q, M, L, D Value range: 0/1 (FALSE/TRUE)
COUNT	The actual value of the counter is output in this parameter. When the value range is exceeded, the following apply: • Upper limit exceeded: the counting process continues with the minimum value in the value range. • Lower limit exceeded: the counting process continues with the maximum value in the value range. Data type: DINT Address ID: I, Q, M, L, D Value range: from -2147483648 to 2147483647
COMP_A	The current COMP_A comparison value is output in this output parameter. Data type: DINT Address ID: I, Q, M, L, D Value range: from -2147483648 to 2147483647
COMP_B	The current COMP_B comparison value is output in this output parameter. Data type: DINT Address ID: I, Q, M, L, D Value range: from -2147483648 to 2147483647
STATUS_A	The output parameter STATUS_A indicates the position of the actual value relative to comparison value COMP_A: • Actual value COUNT ≥ comparison value COMP_A: output parameter STATUS_A enabled • Actual value COUNT < comparison value COMP_A: output parameter STATUS_A not enabled Data type: BOOL Address ID: I, Q, M, L, D Value range: 0/1 (FALSE/TRUE)
STATUS_B	The output parameter STATUS_B indicates the position of the actual value relative to comparison value COMP_B: • Actual value COUNT ≥ comparison value COMP_B: output parameter STATUS_B enabled • Actual value COUNT < comparison value COMP_B: output parameter STATUS_B not enabled Data type: BOOL Address ID: I, Q, M, L, D Value range: 0/1 (FALSE/TRUE)

4.7 Structure of the Instance DB

Instance DB of SFB 29

Table 4-8 shows you the structure and the assignment of the instance DB for the Counter integrated function.

Table 4-8 Instance DB of SFB 29

Address	Symbol	Meaning
DBD 0	PRES_COUNT	Start value of counter
DBD 4	PRES_COMP_A	Comparison value COMP_A (new)
DBD 8	PRES_COMP_B	Comparison value COMP_B (new)
DBX 12.0	EN_COUNT	Software start/stop
DBX 12.1	EN_DO	Enable digital outputs
DBX 12.2	SET_COUNT	Set counter
DBX 12.3	SET_COMP_A	Set comparison value COMP_A
DBX 12.4	SET_COMP_B	Set comparison value COMP_B
DBD 14	COUNT	Actual value of counter
DBD 18	COMP_A	Comparison value COMP_A (current)
DBD 22	COMP_B	Comparison value COMP_B (current)
DBX 26.0	STATUS_A	Status bit A
DBX 26.1	STATUS_B	Status bit B

Length of the Instance DB

The data for the Counter integrated function are 28 bytes in length and begin at address 0 in the instance DB.

4.8 Evaluation of Process Interrupts

Introduction

The Counter integrated function triggers process interrupts on the occurrence of certain events.

Configurable Events

The events which can result in a process interrupt are listed in Table 4-9 together with the parameters you must assign in *STEP 7*.

Table 4-9 Events which can Cause a Process Interrupt

Process Interrupt on	Description	Configuration
Actual value from COMP_A-1 to COMP_A	A process interrupt is triggered when the actual value reaches comparison value COMP_A from below.	Comparison value A reached from below: process interrupt activated
Actual value from COMP_A to COMP_A-1	A process interrupt is triggered when the actual value falls below comparison value COMP_A.	Actual value below comparison value A: process interrupt activated
Actual value from COMP_B-1 to COMP_B	A process interrupt is triggered when the actual value reaches comparison value COMP_B from below.	Comparison value B reached from below: process interrupt activated
Actual value from COMP_B to COMP_B-1	A process interrupt is triggered when the actual value falls below comparison value COMP_B.	Actual value below comparison value B: process interrupt activated

Process Interrupt OB

When a process interrupt occurs, the process interrupt OB (OB 40) is called up. The event which has invoked OB 40 is stored in the start information (declaration section) of the OB 40.

Start Information of OB 40 for Integrated Function

Table 4-10 shows the relevant temporary (TEMP) variables of OB 40 for the Counter Integrated Function of the CPU 312 IFM/314 IFM. You will find a description of OB 40 in the *System and Standard Functions* Reference Manual.

Table 4-10 Start Information of OB 40 for Counter Integrated Function

Variable	Data Type	Description	
OB40_MDL_ADDR	WORD	B#16#7C	Display in local data word 6: • Address of module which triggered interrupt (in this case the CPU)
OB40_POINT_ADDR	DWORD	see Figure 4-9	Display in local data double word 8: • Integrated function which triggered interrupt • Event which triggered interrupt

Display of the Event which Triggered the Interrupt

From the variable OB40_POINT_ADDR you can read which Integrated Function triggered the interrupt and which event led to the triggering of the interrupt. The figure below shows the assignment to the bits of local data doubleword 8.

Please note: If interrupts from different inputs occur at very short time intervals (< 100 μs), several bits can be enabled at the same time. In other words, several interrupts may cause only one OB 40 start.

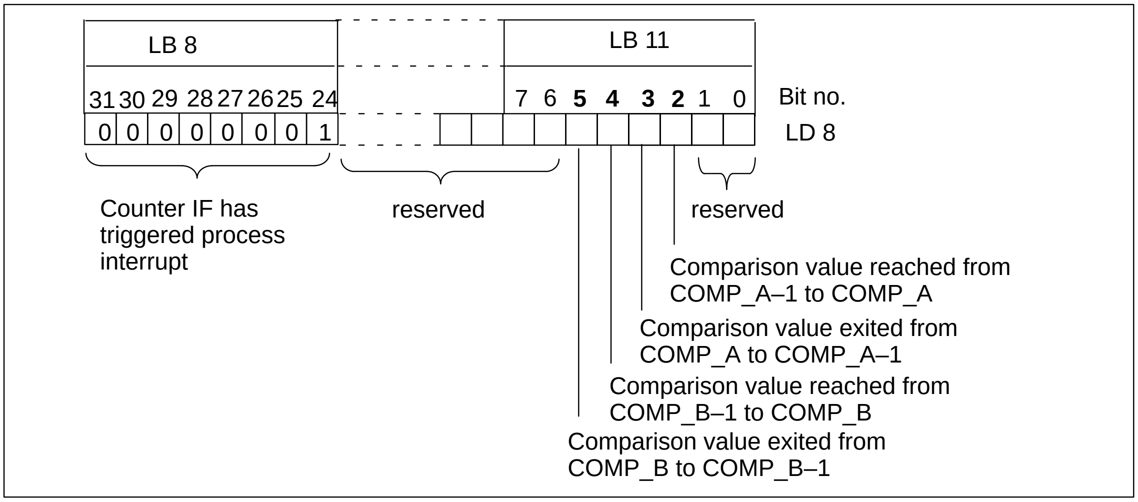

Figure 4-9 Start Information of OB 40: Which Event Triggered Interrupt (Counter IF)?

Evaluation in User Program

The evaluation of process interrupts in the user program is described in the Programming Manual *System Software for S7-300/400, Program Design*.

4.9 Calculating the Cycle Time and Response Times

Introduction

The calculation of the cycle time for the CPUs is described in detail in the manual *S7-300 Programmable Controller, Installation and Hardware*. The following paragraphs describe the times which must be included in the calculation when the Counter integrated function is running.

Calculation

You can calculate the cycle time with the following formula:

Cycle time = $t_1 + t_2 + t_3 + t_4$

t_1 = Process image transfer time (process output image and process input image)[1]

t_2 = Operating system runtime including load generated by an executing integrated function[1]

t_3 = User program execution time[2] including the SFB runtime when an SFB call is made in the program cycle[3]

t_4 = Updating time of the instance DB at the cycle control point (if updating parameterized with *STEP 7*).

Runtime of SFB 29

The runtime of SFB 29 is typically 300 µs.

Instance DB Updating Time

The updating time of the instance DB at the cycle control point is 150 µs for the Counter integrated function.

Increased Cycle Time

Please note that the cycle time can be increased due to:

- Time-controlled execution
- Interrupt handling
- Diagnostics and error handling

1 Please refer to the manual *S7-300 Programmable Controller, Installation and Hardware* for the time required for the CPU 312 IFM.

2 You have to determine the user program execution time, because it depends on your user program.

3 If the SFB is called several times in a program cycle, you should multiply the runtime of the SFB by the number of calls.

Response Time

The response time is the time that elapses from the occurrence of an event at the input to the triggering of a reaction at the output of the programmable controller.

Reactions to Events

Events generated at the inputs by the Counter integrated function can trigger the following:

- Reactions on the integrated inputs/outputs of the CPU
- Reactions of SFB 29

Response Paths

Figure 4-10 illustrates the various response paths.

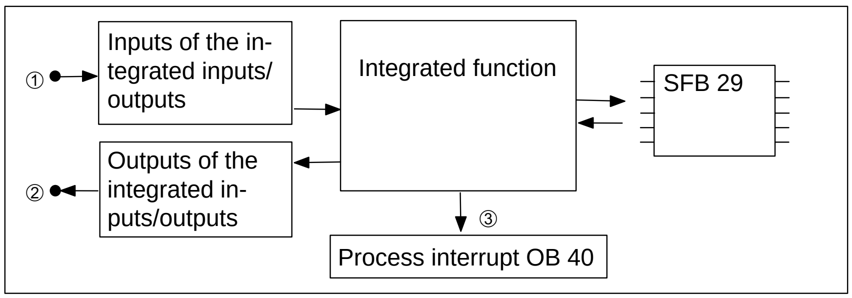

Figure 4-10 Response Paths

Response Times

Each response path results in a different response time. You will find the maximum response times for the Counter integrated function in Table 4-11.

Table 4-11 Response Times of the Counter Integrated Function

Response Path	In Fig. 4-10	Response Time
Integrated inputs/outputs → Integrated inputs/outputs	① → ②	< 1 ms
Integrated inputs/outputs → Process interrupt	① → ③	< 1 ms

4.10 Example Applications

This Section

This section contains 3 application examples of the Counter integrated function which build on each other.

Note

The CPU 312 IFM is used for the application examples. The examples can be implemented in the same way using the CPU 314 IFM provided you take account of the other integrated inputs/outputs (see Table 4-1).

In this Section

4.10.1 Regular Counting with Comparison Value

Task

In a bottling plant, the filled bottles are transported along conveyor belts for packaging in empty crates.

A buffer store is provided for the bottles to ensure that a sufficient number bottles is always available. The buffer store has a limited capacity. If the number of bottles in the buffer store reaches the upper limit of 250, the motor of conveyor 1 is switched off.

An operator can also stop the counting process by activating a normally-closed switch, if a fault occurs or conveyor 1 starts running.

Please note: the example does not include a routine for emptying the buffer store.

Wiring

The technology and wiring of the regular counting process are shown in Figure 4-11.

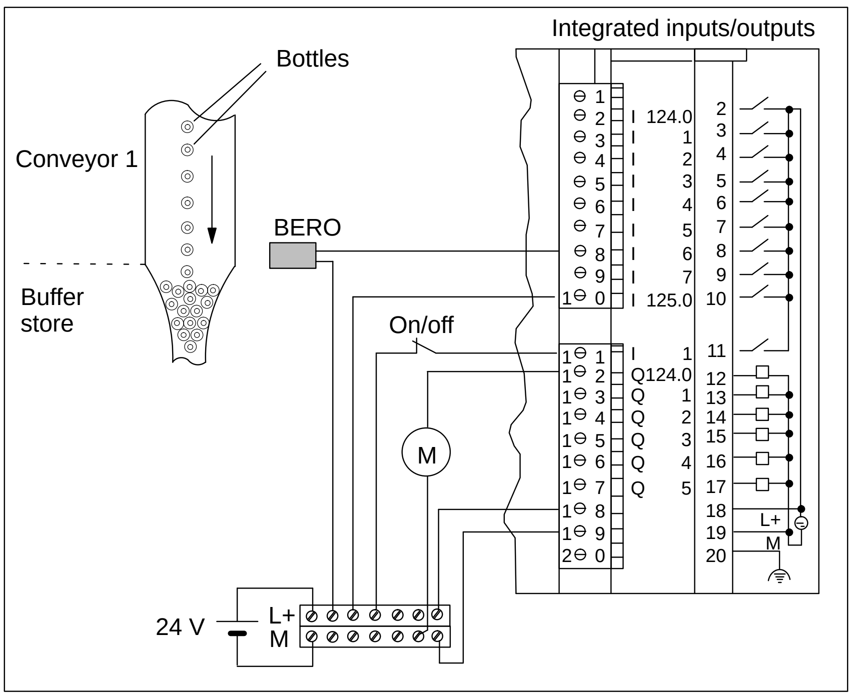

Figure 4-11 Regular Counting with Comparison Value

Function of Inputs and Outputs

The functions of the inputs and outputs for the example are listed in Table 4-12.

Table 4-12 Wiring of the Inputs and Outputs (1)

Terminal	Input/ Output	Function in Example
8	I 124.6	The positive edges are counted upwards. 1 bottle which travels past the BERO proximity switch and into the buffer store triggers 1 positive edge at input 124.6.
10	I 125.0	The Direction digital input is supplied with 24 V, that is the Up digital input counts up and the Down digital input counts down.
11	I 125.1	The counting process can be interrupted by activating the normally-closed switch (at the Hardware Start/Stop digital input).
12	Q 124.0 (Digital output A)	The output is reset when comparison value COMP_A is reached from below. When the number of bottles in the buffer store = 250, conveyor 1 is switched off.
18	L+	24 VDC supply voltage
19	M	Reference potential of supply voltage

Sequence Diagram

The sequence diagram in Figure 4-12 illustrates the relationship between the filling of the buffer store, the interruption of the counting process and the shut-down of the motor.

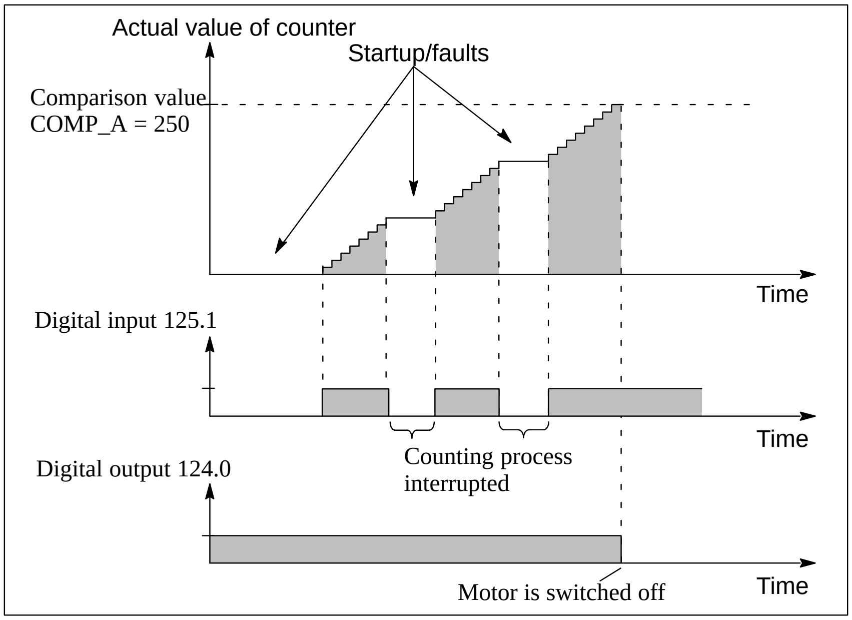

Figure 4-12 Sequence Diagram for Example 1

Parameter Assignment with *STEP 7*

You assign the parameters for the CPU as follows with the STEP 7 tool *S7 Configuration*:

Table 4-13 Parameters for Example 1

Parameter	Input	Description
Counter input: Up	Positive edge	I 124.6 is activated for counting, positive edges are counted
Counter input: Down	Deactivated	I 124.7 is not used for integrated function
Number of instance DB	63	Instance DB for the example (default value)
Automatic updating at the cycle control point[1]	Activated	The instance DB is updated at each cycle control point.
Comparison value reached from below (from COMP_A-1 to COMP_A)		
Digital output A	Off	When the actual value reaches comparison value COMP_A, the motor is switched off
Process interrupt	Deactivated	Process interrupt not triggered

Table 4-13 Parameters for Example 1, continued

Parameter	Input	Description
Reset counter	Deactivated	Counter is not reset to new start value
Set comparator A	Deactivated	New comparison value is not defined

1 Only necessary in CPU 314 IFM

Cyclic Calling of SFB 29

SFB 29 is called cyclically in OB 1. The comparison value 250 and the counter start value 0 are passed to SFB 29.

SFB 29 is illustrated in Figure 4-13.

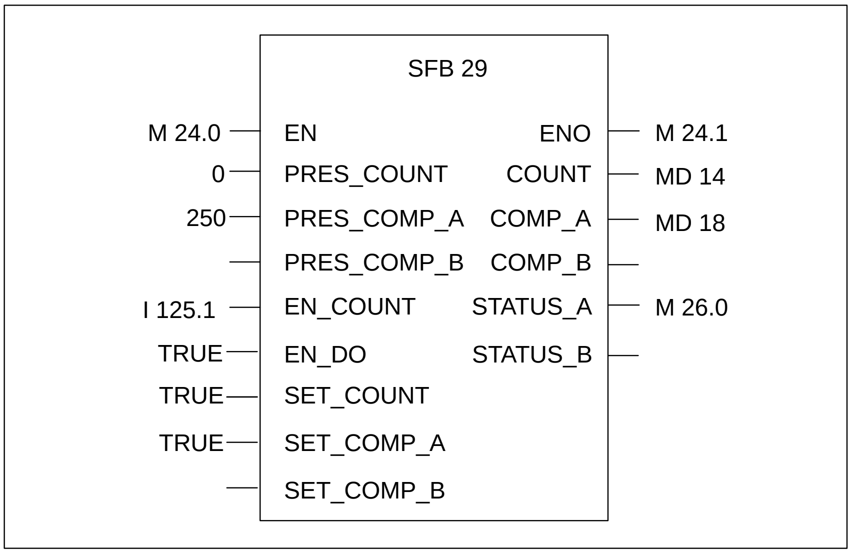

Figure 4-13 Initialization of SFB 29 on Start-Up (1)

Response at Output

As soon as 250 bottles have collected in the buffer store, conveyor 1 is shut down via output 124.0 (digital output A).

Status Bit in User Program

Conveyor 1 is switched on again when status bit A is no longer enabled, that is if there are fewer than 250 bottles in the buffer store.

Instance DB of SFB 29

In the example, the data are stored in instance DB 63.

User Program

The following listing shows the user program for the example. It was created with the *Statement List Editor* in *STEP 7*.

Global Data Used

Table 4-14 shows the global data used in the user program.

Table 4-14 Global Data for Example 1

Global Data	Meaning
MD 14	Actual value of counter
MD 18	Current comparison value A
M 24.0	Enable execution of SFB 29
M 24.1	Store BR bit (= output parameter ENO of SFB 29)
M 26.0	Status bit A
I 125.1	Interrupt counting process
Q 124.0	Actuate motor for conveyor 1

Statement Section OB 100

You enter the following STL user program in the statement section of OB 100:

```
STL (OB 100)                                    Explanation
Network 1

       CALL            SFB 29, DB 63            Call of SFB 29 with instance DB
        PRES_COUNT:    =
        PRES_COMP_A:   =
        PRES_COMP_B:   =
        EN_COUNT:      =

        EN_DO:         =

        SET_COUNT:     = FALSE                  SET_COUNT = 0, to generate pos. edge
                                                in OB 1.
        SET_COMP_A:    = FALSE                  SET_COMP_A = 0, to generate pos. edge
                                                in OB 1.
        SET_COMP_B:    =
        COUNT:         =
        COMP_A:        =
        COMP_B:        =
        STATUS_A:      =
        STATUS_B:      =
       A               BR                       Scan BR bit (= ENO at SFB 29) to enable
       =               M 24.0                   SFB 29 in OB 1
```

OB 1 Statement Section

You enter the following STL user program in the statement section of OB 1:

STL (OB 1)		Explanation
Network 1		
.		Individual user program
.		
.		
A	M 24.0	If M 24.0 = 1, i.e. EN = 1 at SFB 29, SFB is executed;
JNB	m01	If RLO = 0, jump to m01
CALL	SFB 29, DB 63	Call SFB 29 with instance DB
PRES_COUNT:	= L#0	Define start value PRES_COUNT
PRES_COMP_A:	= L#250	Define comparison value PRES_COMP_A
PRES_COMP_B:	=	
EN_COUNT:	= I 125.1	The counting process can be interrupted by activating the normally-closed switch
EN_DO:	= TRUE	Digital outputs are enabled for Counter integrated function
SET_COUNT:	= TRUE	Start value PRES_COUNT is passed
SET_COMP_A:	= TRUE	Comparison value PRES_COMP_A is passed
SET_COMP_B:	=	Assignment of output parameters
COUNT:	= MD 14	
COMP_A:	= MD 18	
COMP_B:	=	
STATUS_A:	= M 26.0	
STATUS_B:	=	
m01: A	BR	Query BR bit (= ENO at SFB 29) for error evaluation
=	M 24.1	
AN	M 26.0	If status bit A not set, conveyor belt 1 runs, Q 124.0 is reset by IF if comparison value COMP_A reached from below.
S	Q 124.0	

4.10.2 Differential Counting

Introduction

The following example is an extension of the example in Section 4.10.1.

Extension of the Task

If the number of bottles in the buffer store falls below 50, a red lamp lights up.

Wiring

The technology and wiring of the differential counting process are shown in Figure 4-14.

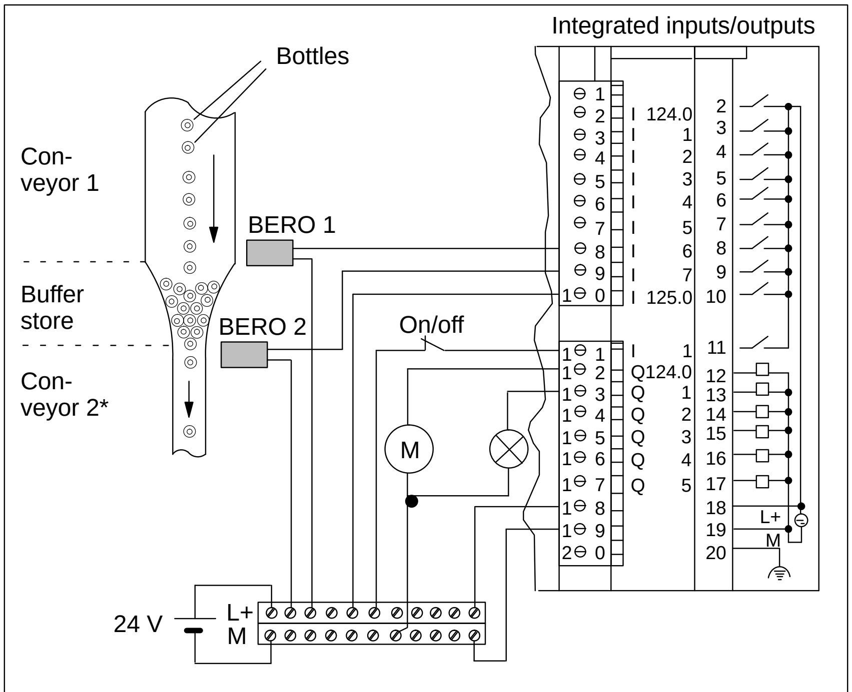

Figure 4-14 Differential Counting

Function of Inputs and Outputs

The functions of the inputs and outputs for the example are listed in Table 4-15.

Table 4-15 Wiring of the Inputs and Outputs (2)

Terminal	Input/ Output	Function in Example
8	I 124.6	The positive edges are counted upwards. 1 bottle which travels past BERO proximity switch 1 and into the buffer store triggers 1 positive edge at input 124.6.
9	I 124.7	The positive edges are counted downwards. 1 bottle which travels past BERO proximity switch 2, that is out of the buffer store on to conveyor 2, triggers 1 positive edge at input 124.7.
10	I 125.0	The Direction digital input is supplied with 24 V, that is the Up digital input counts up and the Down digital input counts down.
11	I 125.1	The counting process can be interrupted by activating the normally-closed switch (at the Hardware Start/Stop digital input).
12	Q 124.0 (Digital output A)	The output is reset when comparison value COMP_A is reached from below. When the number of bottles in the buffer store = 250, conveyor 1 is switched off. The output is set when the value falls below comparison value COMP_A (conveyor 1 is running).
13	Q 124.1 (Digital output B)	The output is set when the value falls below comparison value COMP_B. When the number of bottles in the buffer store falls below 50, the red lamp lights up. The output is reset when comparison value COMP_B is reached from below (red lamp does not light up).
18	L+	24 VDC supply voltage
19	M	Reference potential of supply voltage

Sequence Diagram

The sequence diagram in Figure 4-15 illustrates the relationship between the number of bottles in the buffer store falling below 50 and indication by the red lamp. Conveyor 1 continues to run until the upper limit of 250 bottles has been reached in the buffer store.

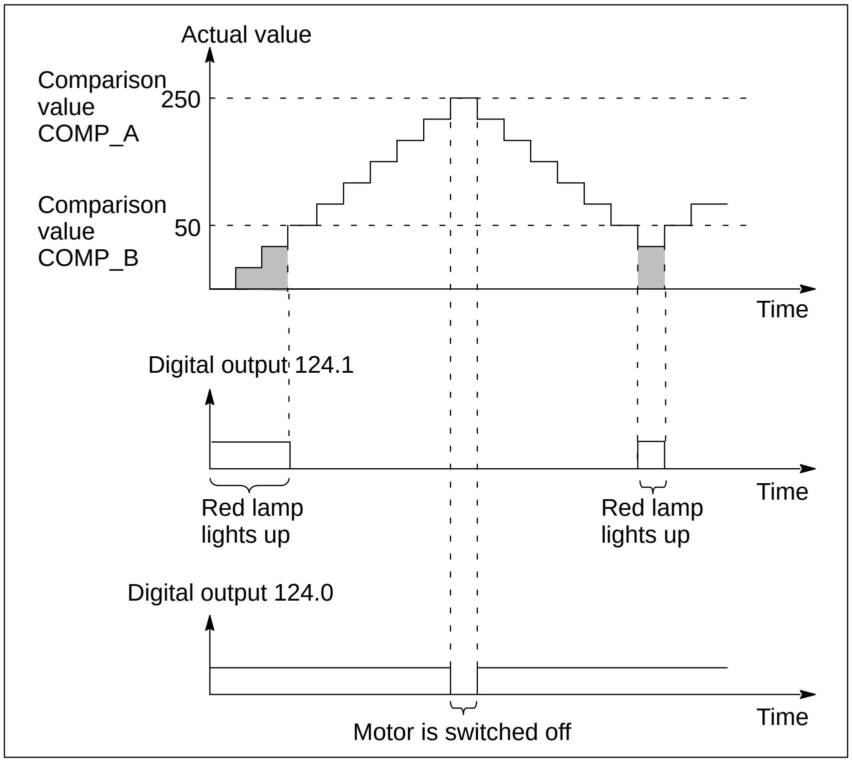

Figure 4-15 Sequence Diagram for Example 2

Parameter Assignment with *STEP 7*

You assign the parameters for the CPU as follows with *STEP 7*:

Table 4-16 Parameters for Example 2

Parameter	Input	Description
Counter input: Up	Positive edge	I 124.6 is activated for counting, positive edges are counted
Counter input: Down	Positive edge	I 124.7 is activated for counting, positive edges are counted
Number of instance DB	63	Instance DB for the example (default value)
Automatic updating at the cycle control point[1]	Activated	The instance DB is updated at each cycle control point
Comparison value reached from below (from COMP_A-1 to COMP_A)		
Digital output A	Off	When the actual value reaches comparison value COMP_A, the motor is switched off
Process interrupt	Deactivated	Process interrupt is not triggered
Reset counter	Deactivated	Counter is not reset
Set comparator A	Deactivated	New comparison value is not specified
Value falls below comparison value (from COMP_A to COMP_A-1)		
Digital output A	On	If the actual value falls below comparison value COMP_A, the motor is switched on.
Process interrupt	Deactivated	Process interrupt is not triggered
Reset counter	Deactivated	Counter is not reset
Set comparator A	Deactivated	New comparison value is not specified
Comparison value reached from below (from COMP_B-1 to COMP_B)		
Digital output B	Off	If the actual value reaches comparison value COMP_B, the red lamp goes out
Process interrupt	Deactivated	Process interrupt is not triggered
Reset counter	Deactivated	Counter is not reset to new start value
Set comparator B	Deactivated	New comparison value is not specified

Table 4-16 Parameters for Example 2, continued

Parameter	Input	Description
Value falls below comparison value (from COMP_B to COMP_B-1)		
Digital output B	On	When the actual value falls below comparison value COMP_B, the red lamp lights up
Process interrupt	Deactivated	Process interrupt is not triggered
Reset counter	Deactivated	Counter is not reset to new start value
Set comparator B	Deactivated	New comparison value is not specified

[1] Only necessary in CPU 314 IFM

Initialization of SFB 29

SFB 29 is called on start-up from OB 100 and initialized. Comparison value 250, comparison value 50 and the start value of counter 0 are transferred to SFB 29 (MD 0, MD 4 and MD 8). Figure 4-16 shows SFB 29 with the initialized input parameters.

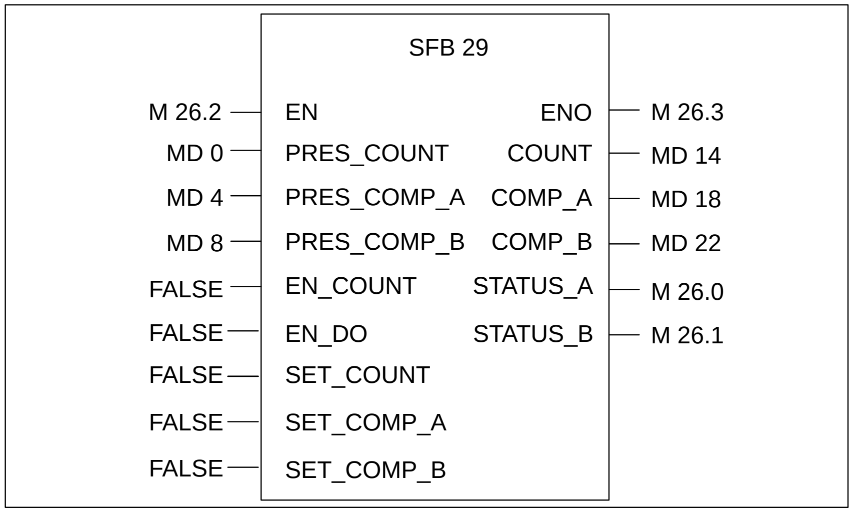

Figure 4-16 Initialization of SFB 29 on Start-Up (2)

Cyclic Calling of SFB 29

SFB 29 is called cyclically in OB 1. The assignment of SFB 29 is illustrated in Figure 4-17.

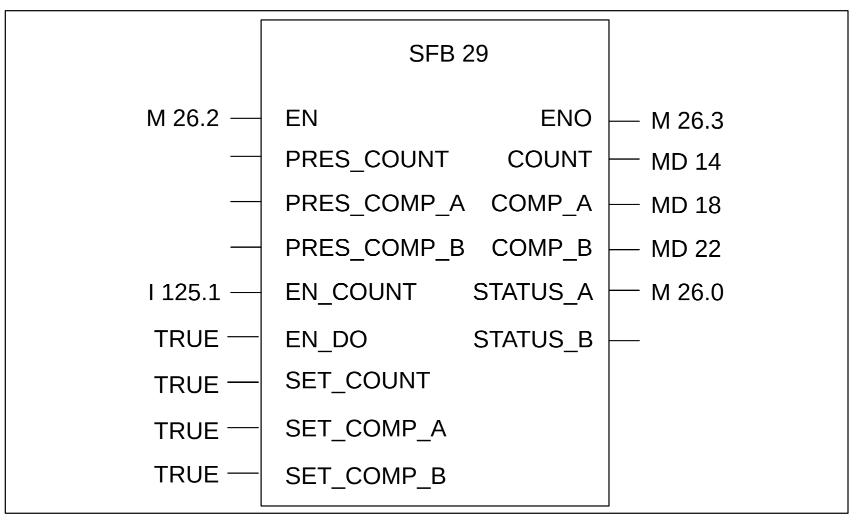

Figure 4-17 Initialization of SFB 29 in the Cyclic Program (2)

Response at Output

As soon as the number of bottles in the buffer store falls below 50, the red lamp is actuated via output 124.1 (digital output B).

Instance DB of SFB 29

In the example, the data are stored in instance DB 63.

User Program

The following listing shows the user program for the example. It was created with the Statement List Editor in STEP 7.

Global Data Used

Table 4-17 shows the global data used in the user program.

Table 4-17 Global Data for Example 2

Global Data	Meaning
MD 0	Start value of counter
MD 4	Comparison value A (new)
MD 8	Comparison value B (new)
MD 14	Actual value of counter
MD 18	Current comparison value A
MD 22	Current comparison value B
M 26.0	Statusbit A
M 26.1	Statusbit B
M 26.2	Enable execution of SFB 29
M 26.3	Store BR bit (= output parameter ENO of SFB 29)
I 125.1	Interrupt counting process
Q 124.0	Actuate motor for conveyor 1
Q 124.1	Actuate red lamp

OB 100 Statement Section

You enter the following statement list (STL) user program in the statement section of OB 100:

```
STL (OB 100)                                  Explanation
Network 1
       L            L#0
       T            MD 0                      Define start value PRES_COUNT in MD 0
       L            L#250                     Define new comparison value PRES_COMP_A
       T            MD 4                      in MD 4
       L            L#50                      Define new comparison value PRES_COMP_B
       T            MD 8                      in MD 8
       SET                                    Enable execution of SFB 29
       =            M 26.2

       A            M 26.2                    If M 26.2 = 1, i.e. EN = 1 at SFB 29,
                                              then SFB is executed;
       JNB          m01                       If RLO = 0, jump to m01

       CALL         SFB 29, DB 63             Call SFB 29 with instance DB
        PRES_COUNT:   = MD 0                  Assignment of input parameters
        PRES_COMP_A:  = MD 4
        PRES_COMP_B:  = MD 8
        EN_COUNT:     = FALSE                 Counter not yet enabled
        EN_DO:        = FALSE                 Digital outputs are not enabled for
                                              Counter integrated function
        SET_COUNT:    = FALSE                 SET_COUNT = 0, to generate pos. edge
                                              in OB 1
        SET_COMP_A:   = FALSE                 SET_COMP_A = 0, to generate pos. edge
                                              in OB 1
        SET_COMP_B:   = FALSE                 SET_COMP_B = 0, to generate pos. edge
                                              in OB 1
        COUNT:        = MD 14                 Assignment of output parameters
        COMP_A:       = MD 18
        COMP_B:       = MD 22
        STATUS_A:     = M 26.0
        STATUS_B:     = M 26.1

m01:   A            BR                        Query BR bit (= ENO at SFB 29) for er-
       =            M 26.3                    ror evaluation

       AN           M  26.1                   Fulfill start condition, i.e. red lamp
       =            Q 124.1                   lights up
       AN           M 26.0                    Conveyor belt on if comparison value
       =            Q 124.0                   COMP_A not yet reached
```

OB 1 Statement Section

You enter the following STL user program in the statement section of OB 1:

```
STL (OB 1)                                         Explanation
Network 1
       .
       .                                           Individual user program
       .
       A               M 26.3                      If M 26.3 = 1, SFB is executed;

       JNB             m01                         If RLO = 0, jump to m01

       CALL            SFB 29, DB 63               Call SFB 29 with instance DB
        PRES_COUNT:    =
        PRES_COMP_A:   =
        PRES_COMP_B:   =
        EN_COUNT:      = E 125.1                   The counting process can be interrupted
                                                   by activating the normally-closed switch
        EN_DO:         = TRUE                      Digital outputs are enabled for Counter
                                                   integrated function
        SET_COUNT:     = TRUE                      Start value PRES_COUNT is transferred

        SET_COMP_A:    = TRUE                      Comparison value PRES_COMP_A is
                                                   transferred
        SET_COMP_B:    = TRUE                      Comparison value PRES_COMP_B is trans-
                                                   ferred
        COUNT:         = MD 14                     Assignment of output parameters
        COMP_A:        = MD 18
        COMP_B:        = MD 22
        STATUS_A:      = M 26.0
        STATUS_B:      =

m01:   A               BR                          Query BR bit (= ENO at SFB 29) for er-
       =               M 26.3                      ror evaluation

                                                   Conveyor belt and lamps (Q 124.0 and
                                                   Q 124.1) switched on and off automati-
                                                   cally by IF.
```

4.10.3 Periodic Counting

Introduction

The following example is an extension of the examples in Sections 4.10.1 and 4.10.2. A second CPU 312 IFM is used for the implementation of the example.

Task

The bottles are transported from the buffer store in empty crates along conveyor 2.

When the maximum capacity of a crate (= 6 bottles) has been reached, conveyor 2 is switched off, the slide is actuated and a time of approximately 5 s is started. During this time, the slide pushes the full crates onto conveyor 3.

When the 5 s are over, the slide is returned to its starting position, conveyor 2 restarts and the counting process starts on a new crate.

The operator can also stop the counting process by means of a normally-closed contact switch if a fault occurs or conveyor 2 starts up.

Technology Plan and Wiring

The technology and wiring of the periodic counting process are shown in Figure 4-18.

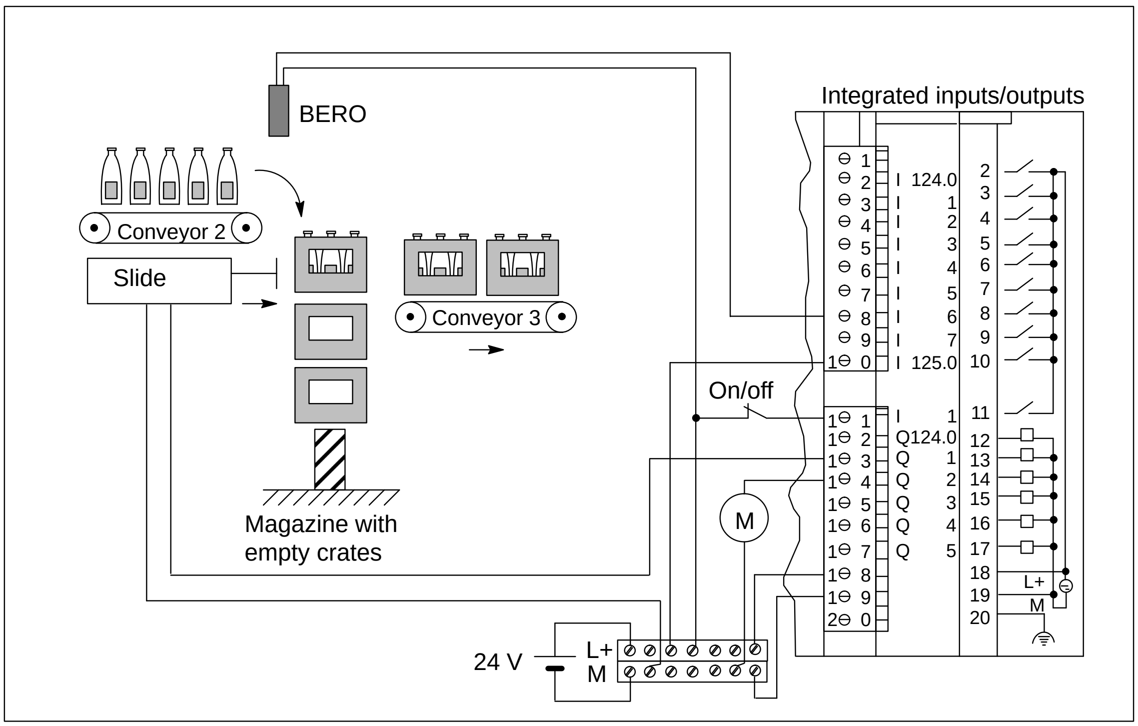

Figure 4-18 Periodic Counting

Function of Inputs and Outputs

The functions of the inputs and outputs for the example are listed in Table 4-18.

Table 4-18 Wiring of the Inputs and Outputs (3)

Terminal	Input/ Output	Function in Example
8	I 124.6	The positive edges are counted upwards. 1 bottle which travels past BERO proximity switch 1 and into the buffer store triggers 1 positive edge at input 124.6.
10	I 125.0	The Direction digital input is supplied with 24 V, that is the Up digital input counts up.
11	I 125.1	The counting process can be interrupted by activating the normally-closed switch (at the Hardware Start/Stop digital input).
13	Q 124.1 (Digital output B)	The output is set by the integrated function when comparison value COMP_B is reached from below. When the maximum capacity of a crate (= 6 bottles) has been reached, a time of approximately 5 s is started during which conveyor 2 is not running and a slide is actuated in order to transport the full crate.
14	Q 124.2	This output is used to actuate the motor for conveyor 2.
18	L+	24 VDC supply voltage
19	M	Reference potential of supply voltage

Sequence Diagram

The sequence diagram in Figure 4-19 illustrates the relationship between reaching the maximum capacity of 6 bottles and the movement of the slide during a defined period.

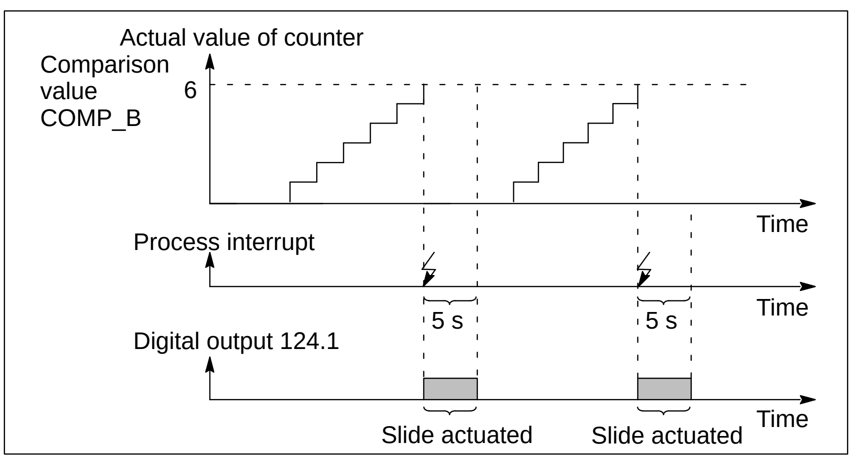

Figure 4-19 Sequence Diagram for Example 3

Parmeter Assignment with *STEP 7*

You assign the parameters for the CPU as follows with *STEP 7*:

Table 4-19 Parameters for Example 3

Parameter	Input	Description
Counter input: Up	Positive edge	I 124.6 is activated for counting, positive edges are counted
Counter input: Down	Deactivated	I 124.7 is not used for integrated function
Number of instance DB	63	Instance DB for the example (default value)
Automatic updating at the cycle control point[1]	Activated	The instance DB is updated at each cycle control point
Comparison value reached from below (from COMP_B-1 to COMP_B)		
Digital output B	On	When the actual value reaches comparison value COMP_B, a time is started and the slide is actuated.
Process interrupt	Activated	Process interrupt is triggered, conveyor belt 2 is stopped and the time for the slide is started.
Reset counter	Activated	Counter is reset to new start value (= 0 bottles)
Set comparator A	Deactivated	New comparison value is not specified

1 Only necessary in CPU 314 IFM

Initialization of SFB 29

SFB 29 is called on start-up from OB 100 and initialized. Comparison value 6 and the starting value of counter 0 are transferred to SFB 29 (MD 0 and MD 8).

SFB 29 is illustrated in Figure 4-20 with the initialized input parameters.

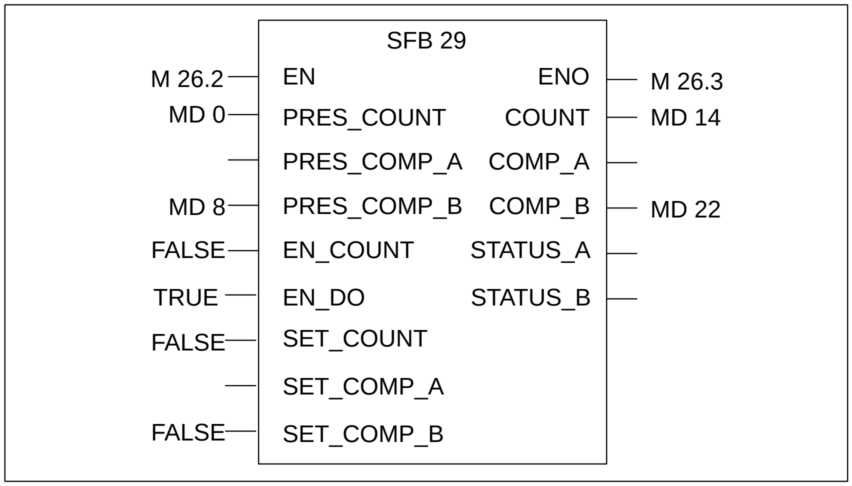

Figure 4-20 Initialization of SFB 29 on Start-Up (3)

Evaluation of the Process Interrupt

The process interrupt starts OB 40. A time of 5 s is started in OB 40.

When the time is started, conveyor 2 is switched off in OB 1 and the slide is triggered by the integrated function. When the time expires, conveyor 2 is switched on again in OB 1.

Instance DB of SFB 29

In the example, the data are stored in instance DB 63.

User Program

The following listing shows the user program for the example. It was created with the *Statement List Editor* in *STEP 7*.

Global Data Used

Table 4-20 shows the global data used in the user program.

Table 4-20 Global Data for Example 3

Global Data	Meaning
MD 0	Start value of counter
MD 8	Comparison value B (new)
MD 14	Actual value of counter
MD 22	Current comparison value B
M 26.2	Enable execution of SFB 29

Table 4-20 Global Data for Example 3

Global Data	Meaning
M 26.3	Storage of BR bit (= output parameter ENO of SFB 29)
T 0	Time for slide actuation
I 125.1	Interrupt counting process
Q 124.1	Actuate slide
Q 124.2	Actuate motor for conveyor 2

OB 100 Statement Section

You enter the following statement list (STL) user program in the statement section of OB 100:

```
STL (OB 100)                                         Explanation
Network 1
       L                L#0                    Define start value PRES_COUNT in MD 0
       T                MD 0

       L                L#6                    Define new comparison value PRES_COMP_B
       T                MD 8                   in MD 8
       SET                                     Enable execution of SFB 29
       =                M 26.2

       A                M 26.2                 If M 26.2 = 1, i.e. EN = 1 at SFB 29,
                                               then SFB is executed;
       JNB              m01                    If RLO = 0, jump to m01

       CALL             SFB 29, DB 63          Call SFB 29 with instance DB
        PRES_COUNT:     = MD 0                 Assignment of input parameters
        PRES_COMP_A:    =
        PRES_COMP_B:    = MD 8
        EN_COUNT:       = FALSE                Counter not yet enabled
        EN_DO:          = TRUE                 Digital outputs are enabled for Counter
                                               integrated function
        SET_COUNT:      = FALSE                SET_COUNT = 0, to generate pos. edge
                                               in OB 1
        SET_COMP_A:     =
        SET_COMP_B:     = FALSE                SET_COMP_B = 0, to generate pos. edge
                                               in OB 1
        COUNT:          = MD 14                Assignment of output parameters
        COMP_A:         =
        COMP_B:         = MD 22
        STATUS_A:       =
        STATUS_B:       =

m01:   A                BR                     Query BR bit (= ENO at SFB 29) for
       =                M 26.3                 error evaluation
```

OB 1 Statement Section

You enter the following STL user program in the statement section of OB 1:

```
STL (OB 1)                                      Explanation
Network 1
       .
       .                                        Individual user program
       .
       SET                                      Motor for conveyor 2 is switched on
       S               A 124.2

       A               M 26.2                   If M 26.2 = 1, i.e. EN = 1 at SFB 29,
                                                then SFB is executed
       JNB             m01                      If RLO = 0, jump to m01

       CALL            SFB 29, DB 63            Call SFB 29 with instance DB
        PRES_COUNT:    =
        PRES_COMP_A:   =
        PRES_COMP_B:   =
        EN_COUNT:      = I 125.1                The counting process can be interrupted
                                                by activating the normally-closed switch
        EN_DO:         =
        SET_COUNT:     = TRUE                   Counter is set at first OB 1 pass

        SET_COMP_A:    =
        SET_COMP_B:    = TRUE                   Comparison value PRES_COMP_P
                                                is set at first OB 1 pass
        COUNT:         = MD 14                  Assignment of output parameters
        COMP_A:        =
        COMP_B:        = MD 22
        STATUS_A:      =
        STATUS_B:      =

m01:   A               BR                       Query BR bit (= ENO at SFB 29) for er-
       =               M 26.3                   ror evaluation

       AN              T 0                      When the time of 5 s has expired, the
       R               A 124.1                  slide is no longer actuated.
                                                As long as the time of 5 s is running,
       A               T 0                      the motor for conveyor 2 is switched
       R               A 124.2                  off and at the same time the slide is
       AN              T 0                      triggered by the integrated function (Q
       FR              T 0                      124.1)
```

OB 40 Statement Section

You enter the following statement list (STL) user program in the statement section of OB 40:

```
STL (OB 40)                                     Explanation
Network 1
       AN              T 0
       L               S5T#5S                   Start timer T 0 for 5 s
       SV              T 0
```

Counter A/B Integrated Function (CPU 314 IFM)

5

In this Chapter

Example Applications

Special applications of the Counter A/B integrated function will not be described in this chapter.

Example applications for the Counter integrated function can be found in Section 4.10 and following sections. You may use these applications as samples for the Counter A/B integrated function.

5.1 Function Overview

Introduction

In this section, you will find an overview diagram (block diagram) for the Counter A/B integrated function of the CPU 314 IFM. The block diagram contains the main components of the integrated function and all its input and output parameters.

Sections 5.2 and 5.3 refer to the block diagram. These sections describe the interaction of the main components of the Counter integrated function and their inputs and outputs.

Purpose of the Integrated Function

The Counter A/B integrated function comprises counters A and B, which can count simultaneously and independently of one another. The principle of operation of both counters is identical.

The Counter A/B integrated function enables the measurement of counting pulses up to a frequency of 10 kHz. The Counter A/B integrated function can count up and down.

Block Diagram

Figure 5-1 shows the block diagram for the Counter A/B integrated function.

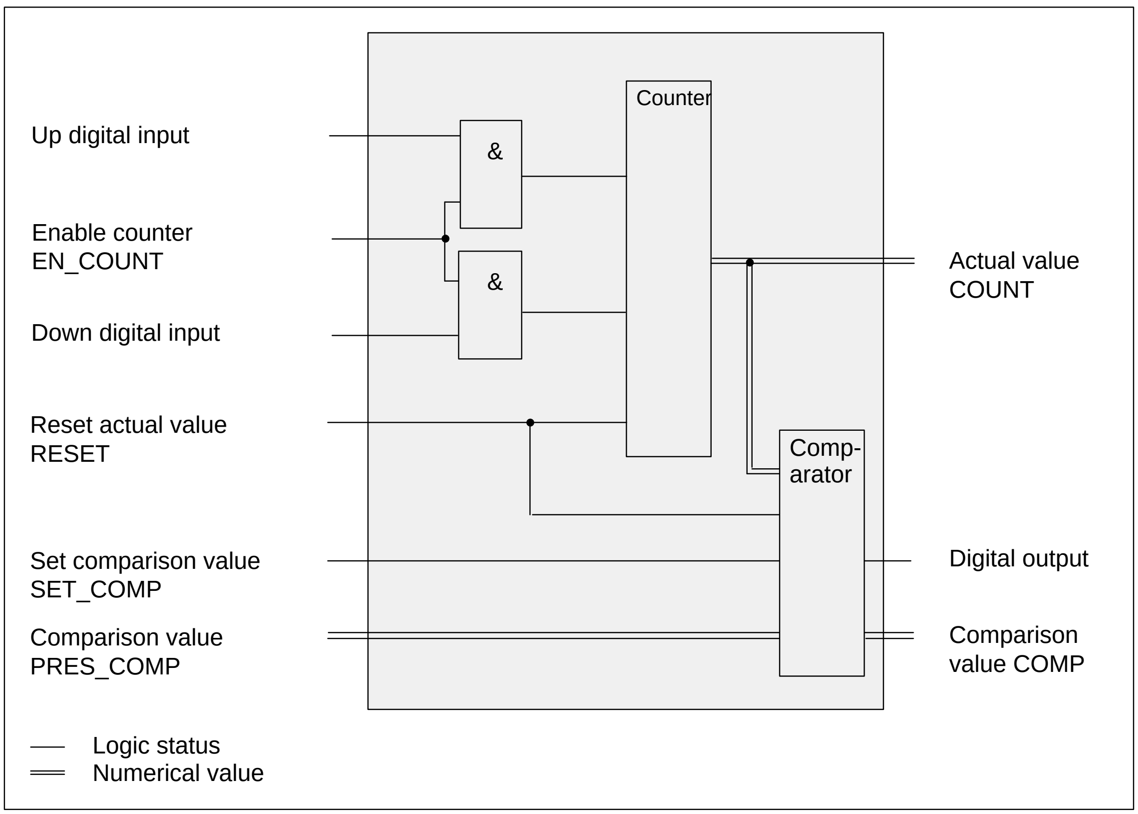

Figure 5-1 Block Diagram for Counter A/B Integrated Function

5.2 How the Counters Operate

Counter

The counter calculates the actual value of the counter from the counting pulses (up and down).

The counting pulses are measured via two digital inputs on the CPU: Up digital input and Down digital input. Only positive edges are evaluated on the digital inputs.

Precondition: You have used *STEP 7* to configure the digital inputs Up and Down (see Section 5.4).

Actual Value of the Counter

The counter calculates the actual value according to the following formula:

Actual value = no. of edges on Up DI - no. of edges on Down DI

Function of the Counter

Figure 5-2 shows an example to illustrate how the actual value of the counter is changed by the counting pulses at the two digital inputs.

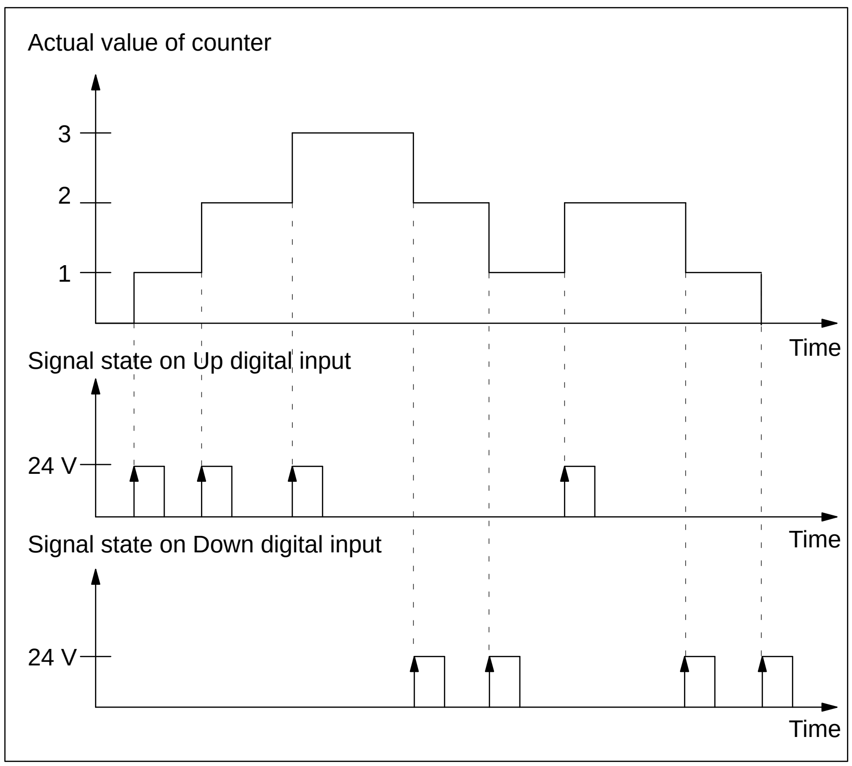

Figure 5-2 Counting Pulses and Actual Value of the Counter

Enable Counter

You can enable the Counter A/B integrated function via the user program by setting input parameter EN_COUNT of SFB 38 to the ‘1’ state.

All incoming counting pulses will be ignored as long as the EN_COUNT input parameter has signal state ‘0’.

Reset Counter via User Program

You can reset the counter to a reset value defined via *STEP 7* in the user program. For this purpose, you have to apply a ‘1’ signal to input parameter RESET of SFB 38.

As long as input parameter RESET has signal state 1, the actual value is reset, i.e. the parameterized reset value is output as the COUNT actual value. The digital output is then set to ‘0’ and no longer controlled by the integrated function.

Reset Counter if Actual Value Reaches Comparison Value

The counter can be reset to a reset value parameterized via *STEP 7*. In *STEP 7*, you can parameterize the integrated function in such a way that it resets the counter if the actual value COUNT reaches the comparison value COMP from below or drops below that value.

Change Counting Direction

A signal change at the digital input for the counting direction causes the up/down digital input to change the counting direction (up if “1” is applied; down if “0” is applied).

Precondition: You have used *STEP 7* to configure the digital inputs Up and Down (see section 5.4).

Frequency Limit Exceeded

The Counter A/B integrated function counts pulses up to a frequency of 10 kHz.

Warning

If the current frequency exceeds the frequency limit of 10 kHz for several milliseconds:

- Correct operation of the integrated function is no longer assured
- The cycle load is increased
- The process interrupt response time is increased
- Communication errors can arise (up to termination of the connection)

When the cycle time watchdog responds, the CPU switches to STOP.

5.3 Function of a Comparator

Comparator

The Counter A/B integrated function has two integrated comparators. A comparator compares the actual value of the counter with a defined comparison value and triggers a reaction on the occurrence of a configured event.

Response of the Comparator to Events

You can configure the following events to which the comparator reacts:

- The actual value of the counter reaches the comparison value from below, that is the actual value changes from COMP-1 (COMP minus 1) to COMP.
- The actual value of the counter falls below the comparison value, that is the actual value changes from COMP to COMP-1.

Example

Figure 5-3 shows an example of all possible events to which the comparator can react.

Defined: comparison value COMP = 100

If the actual value of the counter changes from 99 to 100, a reaction is triggered. If the actual value of the counter changes from 100 to 99, a reaction is triggered.

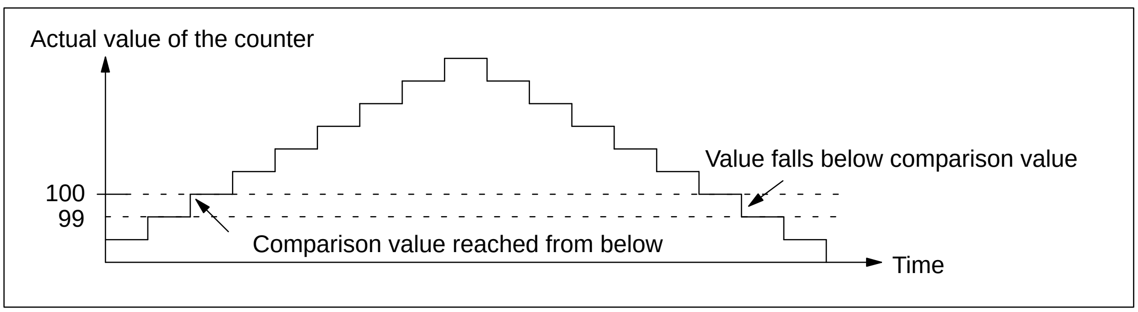

Figure 5-3 Events to which a Comparator Reacts

Configurable Reactions

The following reactions can be triggered when the actual value reaches or falls below the comparison value:

- Set/reset digital output
- Change previous state of the digital output
- Trigger a process interrupt
- Reset the counter
- Set the comparator

You configure the reactions with STEP 7. You will find an overview of the possible parameters and their value ranges in Section 5.4.

Configure Digital Output

You can configure the following properties for the digital output with *STEP 7*:

- On: the digital output is set
- Off: the digital output is reset
- Change: The previous output state changes, i.e. the digital output is either set or reset.
- Unaffected: the state of the digital output remains the same

Example: Trigger Reactions

In Figure 5-4 you can see the reactions of the digital output when the actual value reaches and falls below comparison value COMP. The following parameters were assigned with *STEP 7*:

- Comparison value reached from below: Digital output = on
- Value falls below comparison value: Digital output = unchanged

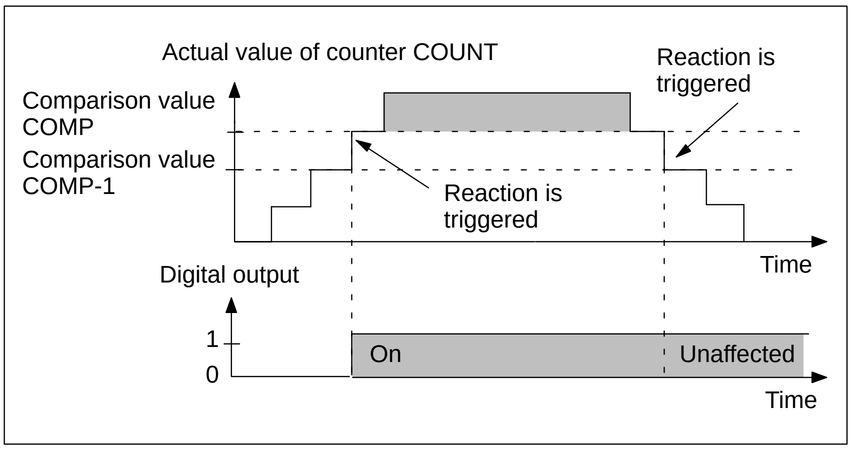

Figure 5-4 Example: Trigger Reactions

Define New Comparison Values

You can define new comparison values with the input parameter PRES_COMP.

The new comparison value is accepted by the comparator:

- On a positive edge on the input parameter SET_COMP.
- On a counter event[1] with parameterized response.

[1] Counter event means the actual value of the counter reaches or leaves a comparison value and the relevant response has been parameterized with *STEP 7*.

5.4 Assigning Parameters

Parameter Assignment with *STEP 7*

You assign the parameters for the integrated function with the integrated function using the *STEP 7 software*. How to work with STEP 7 is described in the manual *Standard Software for S7 and M7, STEP 7*.

Parameters and their Value Ranges

Table 5-1 lists the parameters for the Counter A/B integrated function.

Table 5-1 Counter A/B Register

Parameter	Description	Value Range	Default Setting
Counting signals	You can parameterize digital inputs 126.0 and 126.1 for counter A and digital inputs 126.2 and 126.3 for counter B as follows: • Digital input Up and digital input Down or • Digital input Up/Down and digital input direction (Impulse und Richtung) A signal change at the Direction digital input causes the counting direction to change at the Up/down digital input (Up if “1” is present; down if “0” is present).	Up and down Pulses and direction	Up and down
Reset value	You define a reset value. The actual value of the counter is reset on the reset value if: • If the input parameter RESET of SFB 38 has signal state 1 or • If the actual value reaches the comparison value from below or falls below it (depending on parameter assignment)	-2147483648 to 2147483647	0
Number of the instance DB	The instance DB contains the data exchanged between the integrated function and the user program.	1 to 127	Counter A: 60 Counter B: 61
Automatic updating at the cycle control point	You determine whether the instance DB of the integrated function is to be updated at the cycle control point.	Activated/ deactivated	Activated

Table 5-1 Counter A/B Register, continued

Parameter	Description	Value Range	Default Setting
Actual value reaches comparison value from below (COUNT from COMP–1 to COMP)			
Digital output	You can set the reaction of digital output when the actual value reaches the comparison value from below. Change: The previous output state is changed, i.e. the digital output is either set or reset	Unaffected On Change Off	Unaffected
Process interrupt	You can specify that a process interrupt is to be triggered when the actual value reaches the comparison value from below.	Activated/ deactivated	Deactivated
Reset counter	You can specify that the counter is reset on the reset value when the actual value reaches the comparison value from below.	Activated/ deactivated	Deactivated
Set comparator	You can specify that comparator is set when the actual value reaches the comparison value from below.	Activated/ deactivated	Deactivated
Parameter	**Description**	**Value Range**	**Default Setting**
Actual value falls below comparison value (COUNT from COMP to COMP–1)			
Digital output	You can specify the reaction of digital output when the actual value falls below the comparison value. Change: The previous output state is changed, i.e. the digital output is either set or reset	Unaffected On Change Off	Unaffected
Process interrupt	You can specify that a process interrupt is triggered when the actual value falls below the comparison value.	Activated/ deactivated	Deactivated
Reset counter	You can specify that the counter is reset on the reset value when the actual value falls below the comparison value.	Activated/ deactivated	Deactivated
Set comparator	You can specify that comparator is set when the actual value falls below the comparison value.	Activated/ deactivated	Deactivated

5.5 Wiring

In this Section

5.5.1 Connecting Sensors to the Integrated Inputs/Outputs

Introduction

Two digital inputs per counter are provided at the integrated inputs/outputs for the connection of sensors.

Time Limits

When you set and reset the Direction digital input for counter A and/or B, you must observe the following limits:

- Before the first active edge of the counting pulse: Time ≥ 100 µs
- After the first active edge of the counting pulse: Time ≥ 100 µs

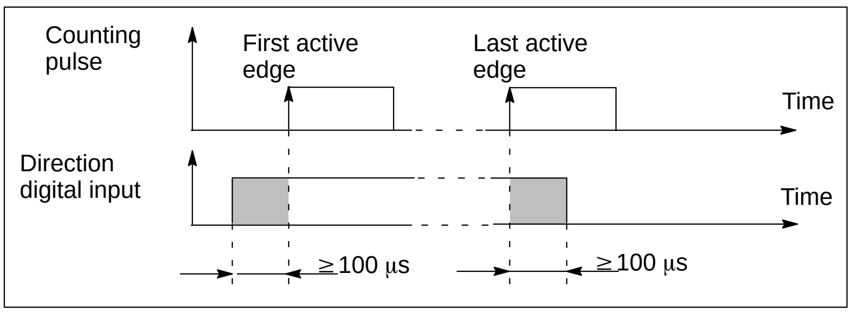

Figure 5-5 Timing of the Direction Digital Inputs for Counters A and B

Terminals

The terminals of the integrated inputs/outputs on the CPU 314 IFM for the Counter integrated function are listed in Table 5-2. The function of the digital inputs has been parameterized by means of *STEP 7* (see Section 5.4).

Table 5-2 Terminals for the Sensors

Terminal	Identifier	Description
2 (special)	I 126.0	Counter A: Up (Up/Down)
3 (special)	I 126.1	Counter A: Down (Direction)
4 (special)	I 126.2	Counter B: Up (Up/Down)
5 (special)	I 126.3	Counter B: Down (Direction)
Connection of CPU power supply	L+	Supply voltage
Connection of CPU power supply	M	Ground

Terminal Connection Model

Figure 5-6 illustrates the connection of the sensors (for example, BERO) to the integrated inputs/outputs for counters A and B.

If you do not want to use only one counter – A or B – connect the sensors to inputs 126.0/126.1 for counter A or 126.2/126.3 for counter B.

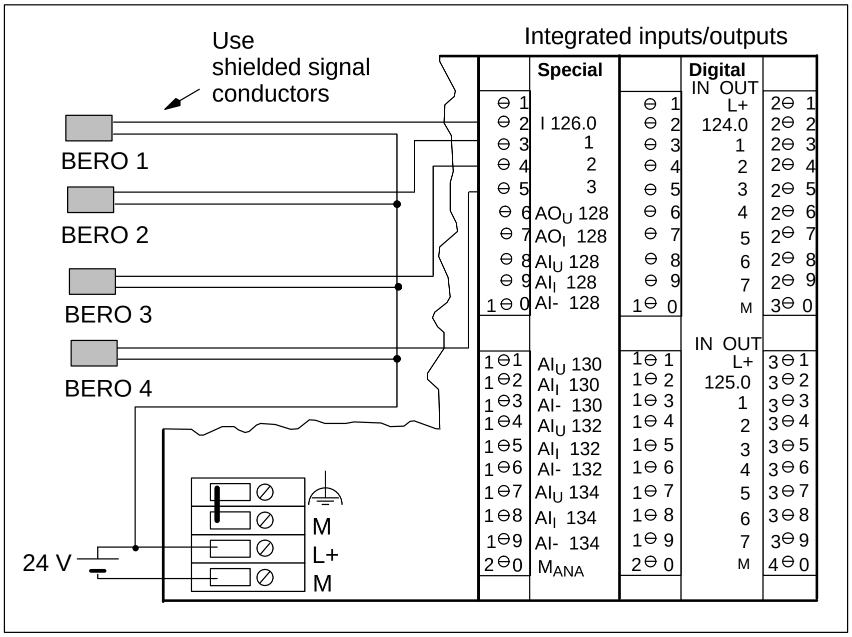

Figure 5-6 Sensor Connecting

Shielding

You must use shielded signal conductors to connect the sensors and you must connect the conductor shields to ground. Use the shield connecting element for this purpose.

You will find more detailed information on the installation of the conductor shield in the manual *S7-300 Programmable Controller, Installation and Hardware*.

5.5.2 Connecting Actuators to the Integrated Inputs/Outputs

Introduction

1 digital output per counter is available for connecting actuators to the integrated inputs/outputs.

Terminals

Table 5-3 shows the relevant terminals.

Table 5-3 Terminals for the Actuators

Terminal	Identifier	Description
21 (digital)	L+	Supply voltage
22 (digital)	Q 124.0	Digital output counter A
23 (digital)	Q 124.1	Digital output counter B
30 (digital)	M	Ground

Terminal Connection Diagram

Figure 5-7 shows an example of how actuators are connected to the digital outputs for counters A and B.

If you want to use only one counter – A or B – connect the actuators to output 124.0 for counter A or 124.1 for counter B.

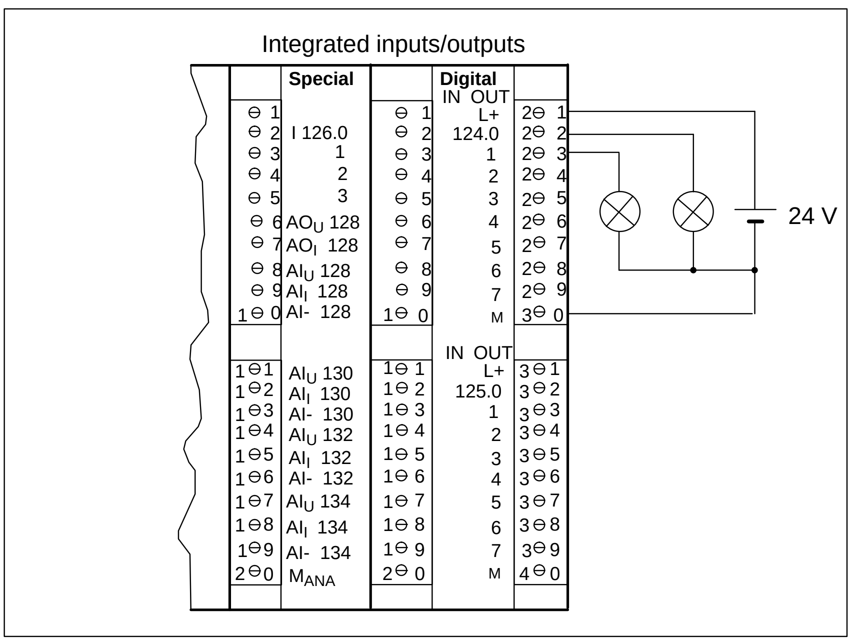

Figure 5-7 Actuator Connecting

5.6 System Function Block 38

Introduction

The Counter A/B integrated function comprises two counters – A and B – that count simultaneously and independent of one another. The principle of operation is the same for both counters. Each counter is assigned to a separate instance DB (see Section 5.7).

The Counter integrated function,i.e. both counters, is assigned to SFB 38. A graphical illustration of SFB 38 is shown in Figure 5-8.

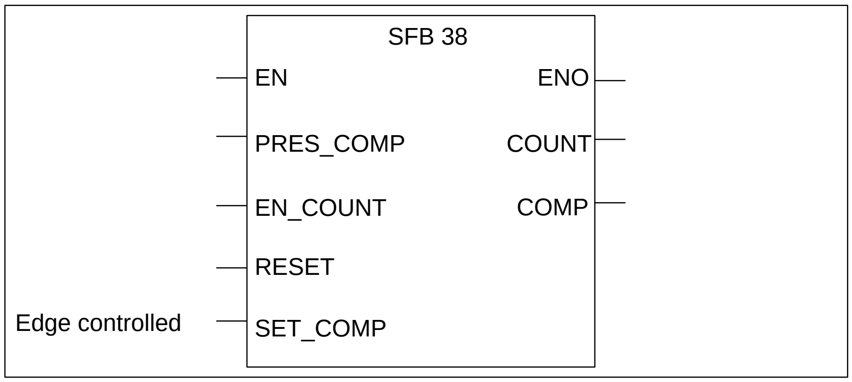

Figure 5-8 Graphical Illustration of SFB 38

Input Parameters of SFB 38

In Table 5-4 you will find a description of the input parameters of SFB 38.

Table 5-4 Input Parameters of SFB 38

Input Parameter	Description
EN	EN is the input parameter for enabling SFB 38. This input parameter causes the SFB to be executed. The input parameter has no effect on the execution of the integrated function. The SFB is executed as long as EN = 1. When EN = 0, the SFB is not executed. Data type: BOOL Address ID: I, Q, M, L, D Value range: 0/1 (FALSE/TRUE)
PRES_COMP	You can use this input parameter to store a new PRES_COMP comparison value. It is accepted following a positive edge on input parameter SET_COMP or on a counting event[1]. Data type: DINT Address ID: I, Q, M, L, D Value range: from –2147483648 to 2147483647
EN_COUNT	As long as a ”0” signal is applied to input parameter EN_COUNT, all incoming counting pulses will be ignored. As long as a ”1” signal is applied to input parameter EN_COUNT, all incoming counting pulses will be evaluated. Data type: BOOL Address ID: I, Q, M, L, D Value range: 0/1 (FALSE/TRUE)

Table 5-4 Input Parameters of SFB 38, continued

Input Parameter	Description
RESET	As long as a “0” signal is applied to input parameter RESET, the counter is ready for operation. As long as a “1” signal is applied to input parameter RESET: • The actual value will be reset, i.e. the parameterized reset value is output as the actual value COUNT. • The digital output is set to signal state 0 and no longer influenced by the integrated function. Data type: BOOL Address ID: I, Q, M, L, D Value range 0/1 (FALSE/TRUE)
SET_COMP	Following a positive edge on this input parameter, comparison value PRES_COMP is accepted. Data type: BOOL Address ID: I, Q, M, L, D Value range 0/1 (FALSE/TRUE)

[1] Counting event means that the actual value of the counter reaches or falls below a comparison value and the corresponding reaction is configured with *STEP 7*.

Output Parameters of SFB 38

In Table 5-5 you will find a description of the output parameters of SFB 38.

Table 5-5 Output Parameters of SFB 38

Output Parameter	Description
ENO	Output parameter ENO indicates whether an error occurred during execution of SFB 38. If ENO = 1, no error occurred. If ENO = 0, SFB 38 was not executed or an error occurred during execution. Data type: BOOL Address ID: I, Q, M, L, D Value range: 0/1 (FALSE/TRUE)
COUNT	The actual value of the counter is output in this parameter. When the value range is exceeded, the following applies: • Upper limit exceeded: the counting process continues with the minimum value in the value range. • Lower limit exceeded: the counting process continues with the maximum value in the value range. Data type: DINT Address ID: I, Q, M, L, D Value range: from –2147483648 to 2147483647
COMP	The current COMP comparison value is output in this output parameter. Data type: DINT Address ID: I, Q, M, L, D Value range: from –2147483648 to 2147483647

5.7 Structure of the Instance DB

Introduction

Each counter of the Counter A/B integrated function is assigned one instance DB:

- for counter A: DB 60
- for counter B: DB 61

The two instance DBs have identical structures.

Instance DB of SFB 38

Table 5-6 shows you the structure and the assignment of the instance DB for the Counter A/B integrated function.

Table 5-6 Instance DB of SFB 38

Address	Symbol	Meaning
DBD 0	PRES_COMP	Comparison value (new)
DBX 4.0	EN_COUNT	Enable
DBX 4.1	RESET	Reset counter
DBX 4.2	SET_COMP	Set comparator
DBD 6	COUNT	Actual value of counter
DBD 10	COMP	Comparison value (current)

Length of the Instance DB

The data for the Counter A/B integrated function are 14 bytes in length and begin at address 0 in the instance DB.

5.8 Evaluation of Process Interrupts

Introduction

The Counter A/B integrated function triggers process interrupts on the occurrence of certain events.

Configurable Events

The events which can result in a process interrupt are listed in Table 5-7 together with the parameters you must assign in *STEP 7*.

Table 5-7 Events which can Cause a Process Interrupt

Process Interrupt on	Description	Configuration
Actual value from COMP–1 to COMP	A process interrupt is triggered when the actual value reaches comparison value COMP from below.	Process interrupt activated
Actual value from COMP to COMP–1	A process interrupt is triggered when the actual value falls below comparison value COMP.	Process interrupt activated

Process Interrupt OB

When a process interrupt occurs, the process interrupt OB (OB 40) is called up. The event which has invoked OB 40 is stored in the start information (declaration section) of the OB 40.

Start Information of OB 40 for Integrated Function

Table 5-8 shows the relevant temporary (TEMP) variables of OB 40 for the Counter Integrated Function of the CPU 312 IFM/314 IFM. You will find a description of OB 40 in the *System and Standard Functions* Reference Manual.

Table 5-8 Start Information of OB 40 for Counter A/B Integrated Function

Variable	Data Type	Description	
OB40_MDL_ADDR	WORD	B#16#7C	Display in local data word 6: • Address of module which triggered interrupt (in this case the CPU)
OB40_POINT_ADDR	DWORD	see Figure 5-9	Display in local data double word 8: • Integrated function which triggered interrupt • Event which triggered interrupt

Display of the Event which Triggered the Interrupt

From the variable OB40_POINT_ADDR you can read which Integrated Function triggered the interrupt and which event led to the triggering of the interrupt. The figure below shows the assignment to the bits of local data doubleword 8.

Please note: If interrupts from different inputs occur at very short time intervals (< 100 µs), several bits can be enabled at the same time. In other words, several interrupts may cause only one OB 40 start.

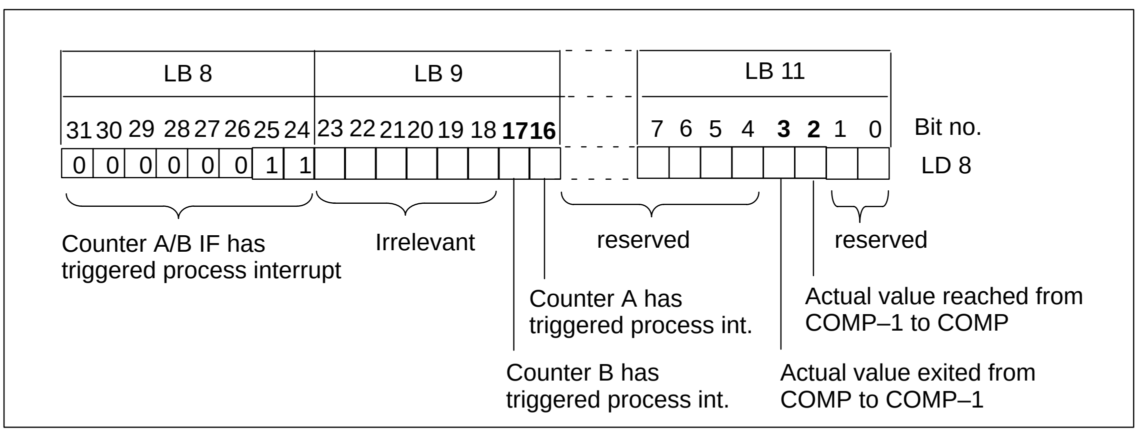

Figure 5-9 Start Information of OB 40: Which Event Triggered Interrupt (Counter A/B IF)?

Evaluation in User Program

The evaluation of process interrupts in the user program is described in the Programming Manual *System Software for S7-300/400, Program Design*.

5.9 Calculating the Cycle Time and Response Times

Introduction

The calculation of the cycle time for the CPU 314 IFM is described in detail in the manual *S7-300 Programmable Controller, Installation and Hardware*. The following paragraphs describe the times which must be included in the calculation when the Counter A/B integrated function is running.

Calculation

You can calculate the cycle time with the following formula:

Cycle time = $t_1 + t_2 + t_3 + t_4$

t_1 = Process image transfer time (process output image and process input image)[1]

t_2 = Operating system runtime including load generated by an executing integrated function[1]

t_3 = User program execution time[2] including the SFB runtime when an SFB call is made in the program cycle[3]

t_4 = Updating time of the instance DB at the cycle control point (if updating parameterized with *STEP 7*).

Runtime of SFB 38

The runtime of the SFB is typically 230 µs.

Instance DB Updating Time

The updating time of the instance DB at the cycle control point is 100 µs for the Counter A/B integrated function.

Increased Cycle Time

Please note that the cycle time can be increased due to:

- Time-controlled execution
- Interrupt handling
- Diagnostics and error handling

[1] Please refer to the manual *S7-300 Programmable Controller, Installation and Hardware* for the time required for the CPU 314 IFM.

[2] You have to determine the user program execution time, because it depends on your user program.

[3] If the SFB is called several times in a program cycle, you should multiply the runtime of the SFB by the number of calls.

Response Time

The response time is the time that elapses from the occurrence of an event at the input to the triggering of a reaction at the output of the programmable controller.

Reactions to Events

Events generated at the inputs by the Counter A/B integrated function can trigger the following:

- Reactions on the integrated inputs/outputs of the CPU 314 IFM
- Reactions of SFB 38

Response Paths

Figure 5-10 illustrates the various response paths.

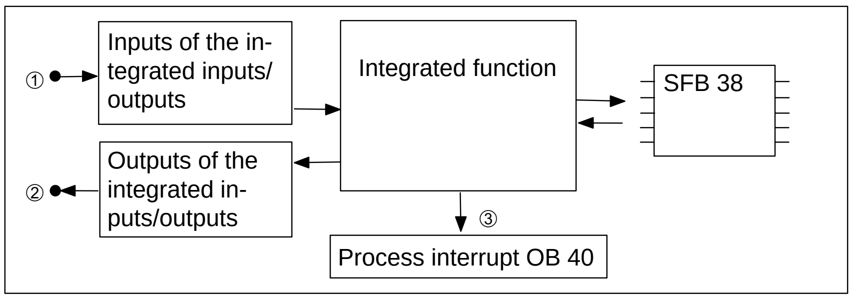

Figure 5-10 Response Paths

Response Times

Each response path results in a different response time. You will find the maximum response times for the Counter A/B integrated function in Table 5-9.

Table 5-9 Response Times of the Counter Integrated Function

Response Path	In Fig. 4-10	Response Time
Integrated inputs/outputs → Integrated inputs/outputs	① → ②	< 1 ms
Integrated inputs/outputs → Process interrupt	① → ③	< 1 ms

Positioning Integrated Function (CPU 314 IFM)

6

Introduction

The Positioning integrated function of the CPU 314 IFM provides functions enabling open-loop positioning of axes in conjunction with a user program.

Performance Features

The Positioning integrated function does the following:

- Acquire signals from asymmetrical 24-V incremental encoders up to a frequency of 10 kHz
- Acquire a 24-V signal on the traverse path for synchronizing the actual value (hardware synchronization)
- Enable synchronization via a control bit (software synchronization)
- Control a rapid traverse/creep speed drive or a frequency converter via digital outputs and an analog output of the integrated I/O

Incorporating the Integrated Function

The Positioning integrated function is incorporated into the user program by specifying control data and by evaluating the status messages to a system function block (SFB).

In this Chapter

6.1 Introduction to the Positioning Integrated Function

Content of this Section

In this section, you will learn the basics of reference point approach, jog mode and controlling drives, and you will find special information concerning the Positioning integrated function of the CPU 314 IFM.

Who Should Read this Section?

If you have little or no experience of open-loop positioning, we recommend that you read this section.

In this Section

Pulse Evaluation

You will find information on pulse evaluation via the Positioning integrated function in Appendix D.

6.1.1 Encoders and Power Sections for the Positioning Integrated Function

Encoder Classification

In positioning, the path is acquired by an encoder. Encoders can be classified as follows:

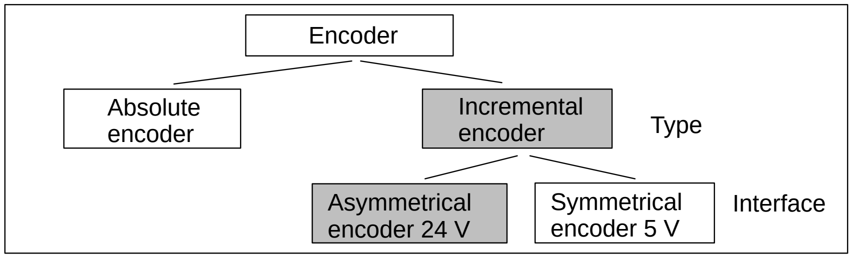

Figure 6-1 Encoder Classification

24-V Asymmetrical Encoders

Asymmetrical encoders are incremental encoders that generate two pulse trains A and B, phase-shifted by 90°, which are used for counting the path increments and for acquiring the direction.

Encoders for the CPU 314 IFM

You can only connect one asymmetrical incremental encoder (24 V) to the Positioning integrated function of the CPU 314 IFM. We recommend you use a SIEMENS incremental encoder (see Appendix D).

Signal Shapes

Figure 6-2 shows the shape of signals from 24-V asymmetrical encoders. You will find information on pulse evaluation via the Positioning integrated function in Appendix D.

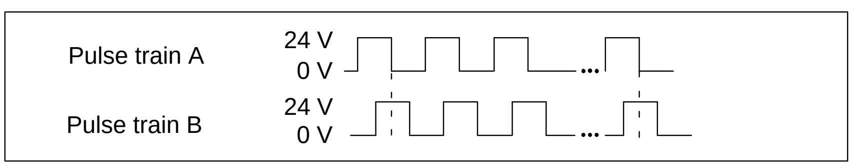

Figure 6-2 Signal Shapes of Asymmetrical Incremental Encoders

Zero Mark Signal of the Encoders

Most incremental encoders supply at each revolution a zero mark signal that can be used for synchronization. If you want to evaluate the zero mark signal, you will find details in Section 6.6.1 of how to connect it to the integral inputs/outputs.

Classification According to Drive Control

In a positioning operation, the position is measured at moved parts. The movement is generated by a drive.

Application examples for positioning can be classified as follows according to drive control:

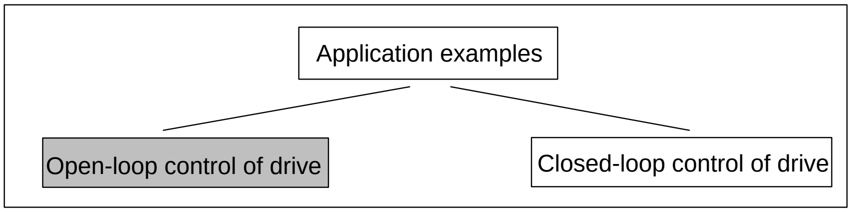

Figure 6-3 Classification According to Drive Control

Drives for the CPU 314 IFM

The Positioning integrated function of the CPU 314 IFM can perform open-loop control of electrical drives but not closed-loop control.

Power Section

Instead of controlling the drive direct, the CPU 314 IFM does so via a power section.

Power Sections for the CPU 314 IFM

Table 6-1 lists the power sections that can be controlled by the Positioning integrated function.

Table 6-1 Power Sections and Drives

Power Section ...	**... drives**
Contactor circuit	polarity-reversible asynchronous motor with velocity specified in steps (rapid traverse/creep speed)
Frequency converter	asynchronous or synchronous motor with stepless velocity specification

6.1.2 Reference Point Approach

Introduction

An incremental encoder supplies a train of pulses. The position of the axis relative to a reference point can be calculated from this pulse train. A reference point approach is required in order to synchronize the actual position of the axis with the actual value of the integrated function.

We show below how a reference point approach is carried out using the Positioning integrated function.

Example

Let's take as an example a worktable which is used to position workpieces.

One or more machining operations are performed at a machining point. In the example below, holes are drilled in a workpiece. The worktable is stopped at the relevant position until machining is completed.

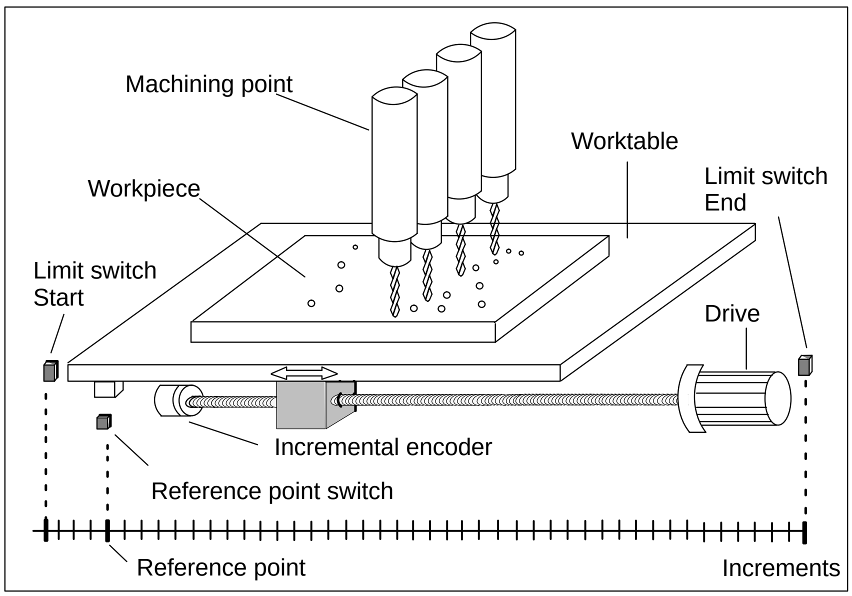

Figure 6-4 Worktable Example

Reference Point Switch

A reference point switch (for example, a BERO) is fitted at the reference point. When the reference point switch trips, the worktable has reached the reference point. The actual position of the axis is synchronized to the actual value of the integrated function.

Accuracy of the Reference Point

In practice, the reference point switch is implemented with a cam that is acquired with a switch, for example, a BERO.

The reference point switch supplies signal state 1 over a distance corresponding to the width of the cam.

In order to ensure a certain accuracy of the reference point,

- the reference point is assigned to the first counting pulse (increment) after the rising edge and
- the edge of the reference point switch is only evaluated if the reference point switch is reached from a specified direction.

Whether the reference point switch is to be evaluated from the forward or backward direction is parameterized with *STEP 7*.

Figure 6-5 shows the evaluation of the reference point switch when the forward direction has been parameterized with *STEP 7*.

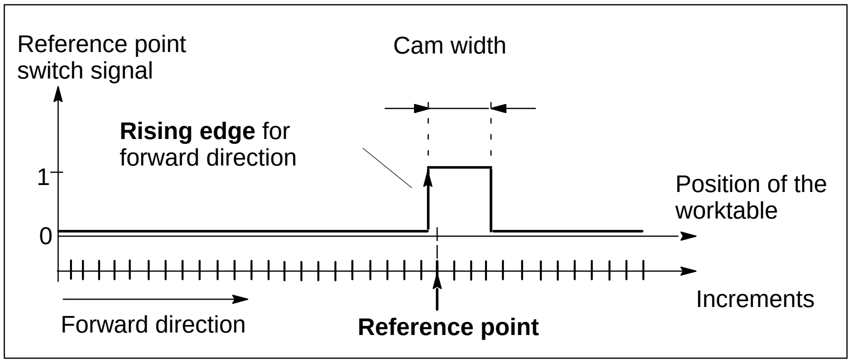

Figure 6-5 Evaluation of the Reference Point Switch

Repeat Accuracy

There is no guarantee that the edges of the reference point switch will always occur at exactly the same position on the axis since switches such as BEROs have a limited repeat accuracy.

Typical values for the repeat accuracy:

- Mechanical switches 10 µm
- Forked light barriers 100 µm
- BEROs 500 µm

The actual repeat accuracy depends strongly on the special switch. The repeat accuracy also depends on external factors such as the velocity at which the switch is reached. You will find detailed information in the Product Information on the switch.

6.1.3 Jog Mode

Jog Mode

Jog mode means moving the axis ’manually’ to any position.

You execute jog mode either via the user program or via an operator panel (OP).

Using Jog Mode

You use jog mode:

① If you want to move the axis ’manually’ to a position

② For synchronizing the Positioning integrated function with the actual position of the axis

① Moving the Axis Manually

To correct faults on the machine, the axis has to be moved to a specific position. It must also be possible to do this even when the Positioning integrated function is not synchronized.

② Synchronization of the Integrated Function

When the CPU 314 IFM is switched on, the Positioning integrated function cannot calculate the actual position of the axis because a reference point switch has not yet been reached and so the reference point has not yet been set. The Positioning integrated function is not synchronized with the axis and therefore cannot control a positioning operation.

To synchronize, move the axis in jog mode over a reference point switch.

Synchronization Example

The ’Worktable positioning’ example is considered again below (see Figure 6-4).

After switching on the system, the Positioning integrated function is synchronized as follows:

Regardless of the actual position of the worktable, the user program controls the worktable in jog mode until it reaches the start of the limit switch.

Following this, the user program controls the worktable in jog mode in the forward direction. The reference point switch is reached on the traverse and the actual position of the worktable is synchronized to the actual value of the integrated function.

Selecting Jog Mode

You select jog mode via the user program.

Velocity in Jog Mode

You specify the velocity with which jog mode is to execute via the user program. The velocity you can specify depends on the power section used.

For the contactor circuit, you can move the axis in jog mode at rapid traverse or at creep speed.

More velocities are possible for a frequency converter. The procedure for defining the velocity is given in Section 6.7 in Table 6-11.

6.1.4 Controlling Rapid Traverse/Creep Speed Drives

Controllable Drives

The Positioning integrated function can control either:

- A rapid traverse and creep speed drive or
- A frequency converter

Contactor Circuit

Contactor circuits are used for driving polarity-reversible asynchronous motors.

Two different velocities can be implemented with polarity-reversible asynchronous motors - rapid traverse and creep speed.

Velocity Profile

Figure 6-6 shows the velocity profile of a rapid traverse and creep speed drive. It applies both for a positioning operation as well as for jog mode.

The destination position is first approached at a higher velocity (rapid traverse). At a specified distance from the destination position, the system switches to a lower velocity (creep speed). Shortly before the axis reaches the destination position, also at a specified distance to the destination position, the drive is switched off.

Creep speed serves only to increase positioning accuracy and corresponds to the stopping distance.

You paramaterize the stopping distance with *STEP 7*. The switch-off difference is specified via the user program.

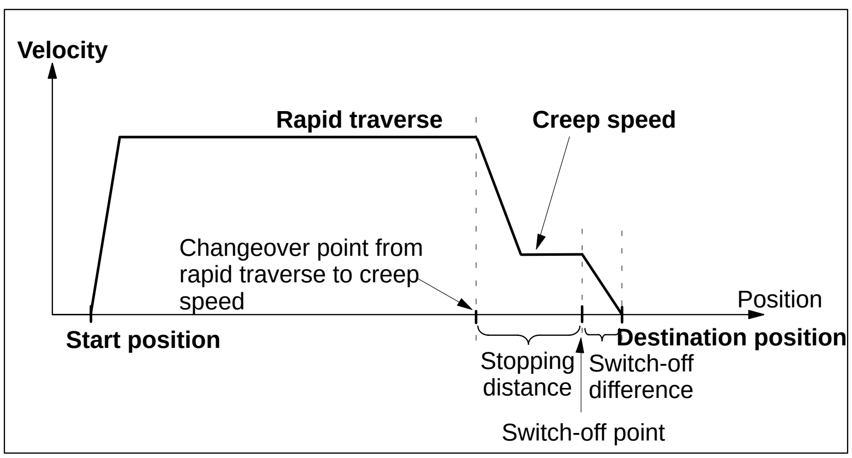

Figure 6-6 Velocity Profile in the Case of Rapid Traverse and Creep Speed Drives

Special feature: If the distance between the start position and the destination position is less than or equal to the switch-off difference, the positioning operation is not executed.

Control via 4 Digital Outputs

The CPU 314 IFM has one digital output for switching the drive to rapid traverse and one for switching it to creep speed.

The direction of rotation of the drive is specified via 2 further digital outputs.

Figure 6-7 shows the behavior of the relevant digital outputs during a positioning operation.

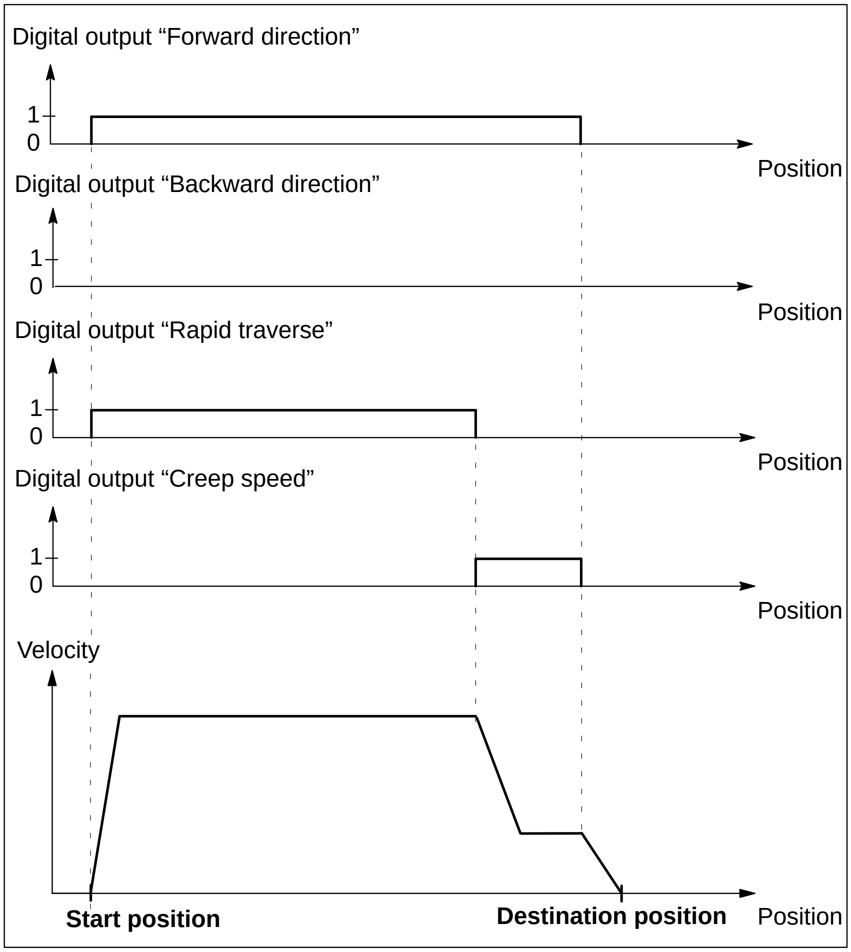

Figure 6-7 Positioning Operation in Forward Direction in the Case of Rapid Traverse and Creep Speed Drives

6.1.5 Controlling the Drive via Frequency Converters

Frequency Converters

Frequency converters are used for driving asynchronous motors or synchronous motors.

Determining the Velocity Profile

The Positioning integrated function controls frequency converters with a velocity profile determined as follows:

- A maximum permissible velocity must not be exceeded. A maximum velocity must not be exceeded for mechanical reasons.
- A maximum permissible acceleration must not be exceeded. The acceleration forces working on a workpiece must not exceed a fixed maximum acceleration.
- The positioning operation should execute time-optimally under the above-named stipulations.

Velocity Profile

Figure 6-8 shows the velocity profile and acceleration profile of the drive within a positioning operation. This is an ideal representation and the drive is accelerated to maximum velocity/decelerated to standstill in 10 steps. The profiles apply both for a positioning operation and for jog mode. You specify the maximum velocity in the user program and you parameterize the acceleration and stopping distance with *STEP 7*.

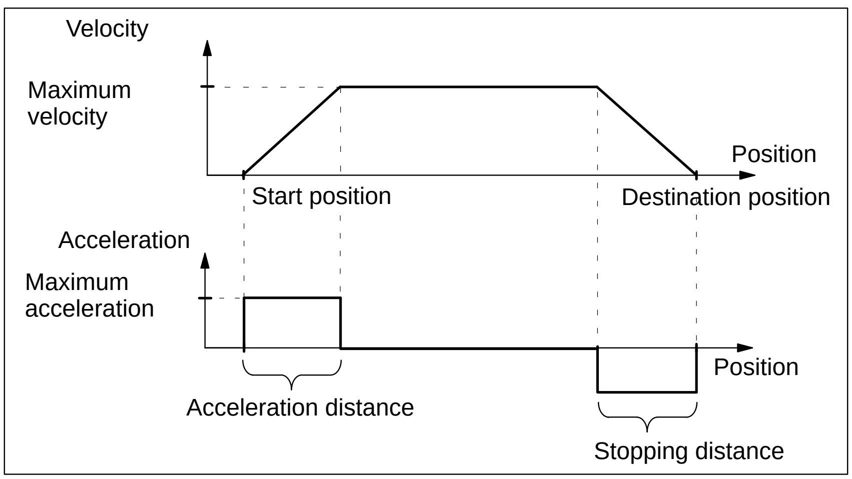

Figure 6-8 Velocity/Acceleration Profile in the Case of Frequency Converters

Switch-Off Difference

Figure 6-9 shows the velocity of the drive within a positioning operation. In the inset, you can see the switch-off difference that you specify via the user program.

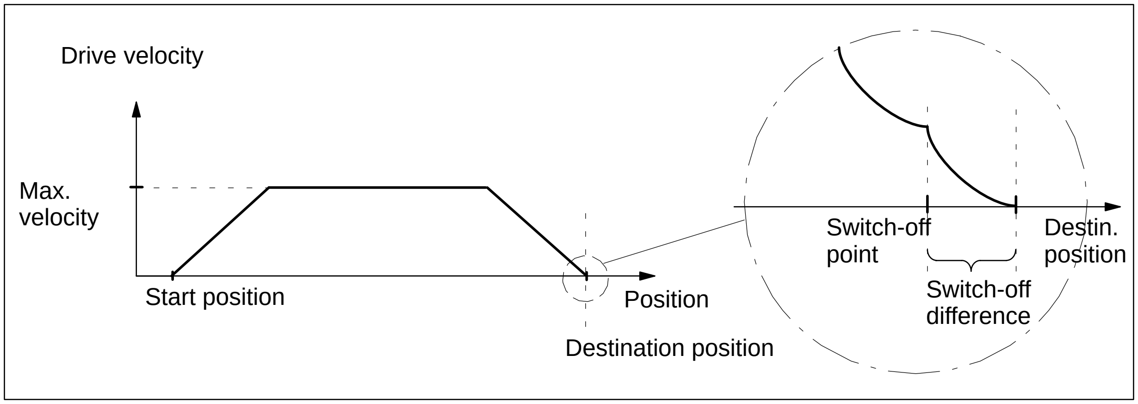

Figure 6-9 Switch-Off Difference when Controlling a Frequency Converter

Special Feature: If the distance between the start position and the destination position is ≤ the switch-off difference, the positioning operation is not executed.

Controlling Frequency Converters

Frequency converters are controlled either via:

- 1 analog output (signal 0 to 10 V or 0 to 20 mA) for specifying the velocity and
  2 digital outputs for specifying the direction (forward, backward)

  or via

- 1 analog output (signal ± 10 V or ± 20 mA) for specifying the velocity and the direction (forward, backward)

Output of Analog Values

The analog values are output in steps (see Section 6.4).

Control via 1 Analog Output and 2 Digital Outputs

The velocity of a drive is specified to the frequency converter as an analog signal 0 to 10 V or 0 to 20 mA. The maximum specifiable velocity corresponds to 10 V or 20 mA. You determine the maximum velocity in the user program.

It is up to you whether you use a voltage or a current value as the analog signal.

The direction of rotation of the drive is specified via 2 digital outputs.

Figure 6-10 shows the analog values at the analog output and the behavior of the relevant digital outputs.

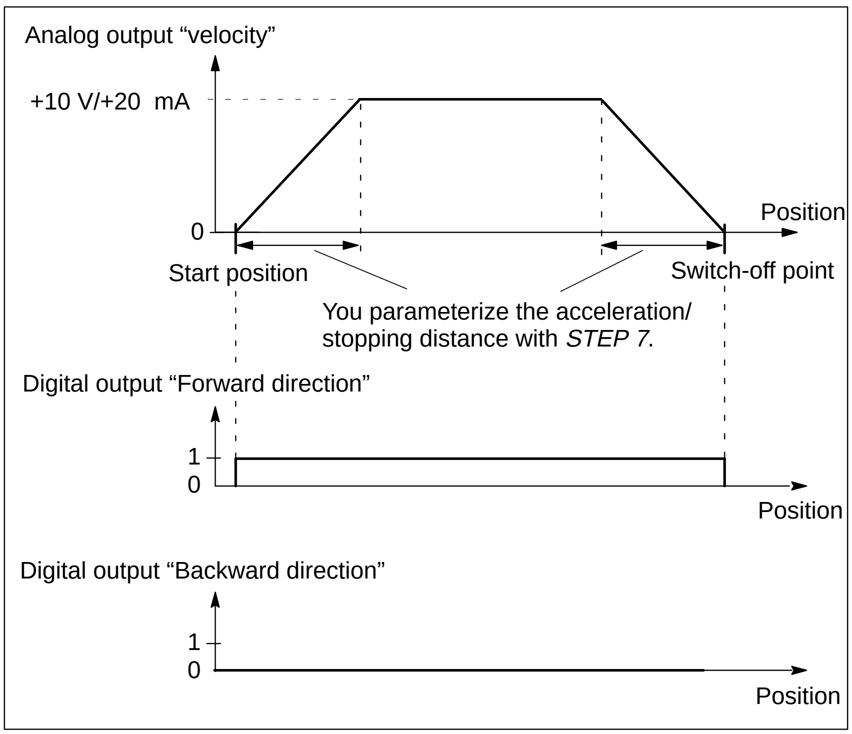

Figure 6-10 Positioning Operation in Forward Direction (1 Analog and 2 Digital Outputs for Frequency Converter)

Control via 1 Analog Output

The velocity of the drive is specified to the frequency converter as an analog signal ± 10 V or ± 20 mA. The maximum specifiable velocity corresponds to +10 V or -10 V and +20 V or -20 V, respectively. You determine the maximum velocity in the user program.

It is up to you whether you use a voltage or a current value as the analog signal.

The direction of rotation of the drive is specified via the sign of the analog voltage/analog current.

Figure 6-11 shows the velocity at the analog output during a positioning operation.

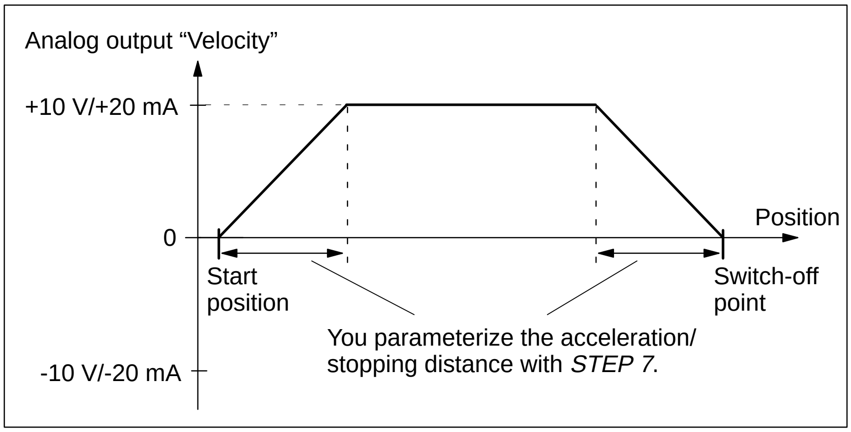

Figure 6-11 Positioning Operation in Forward Direction (1 Analog Output for Frequency Converters)

6.2 Functional Principle of the Positioning Integrated Function

Overview

Figure 6-12 gives an overview of the inputs and outputs of the Positioning integrated function and the way in which they work together with the user program CPU 314 IFM.

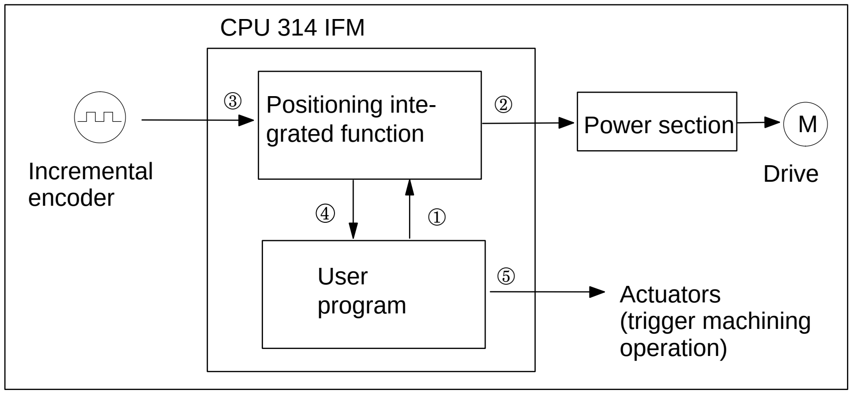

Figure 6-12 Inputs and Outputs of the Positioning Integrated Function

Positioning Operation Sequence

Table 6-2 explains Figure 6-12 using a positioning operation example.

Table 6-2 Positioning Operation Sequence

No.	Sequence Description
①	You start a positioning operation via the user program.
②	The Positioning integrated function starts the drive and controls the velocity of the drive until the switch-off point is reached.
③	The actual position is acquired so that the Positioning integrated function can control the drive.
④	The Positioning integrated function signals the completion of the positioning operation to the user program.
⑤	All further responses relevant to the machining of the positioned workpiece are initiated by the user program.

Inputs and Outputs

Figure 6-13 shows the hardware and software inputs/outputs of the Positioning integrated function. The functions of the inputs and outputs are then explained. The structure of SFB 39 (software inputs/outputs) is explained in detail in Section 6.7.

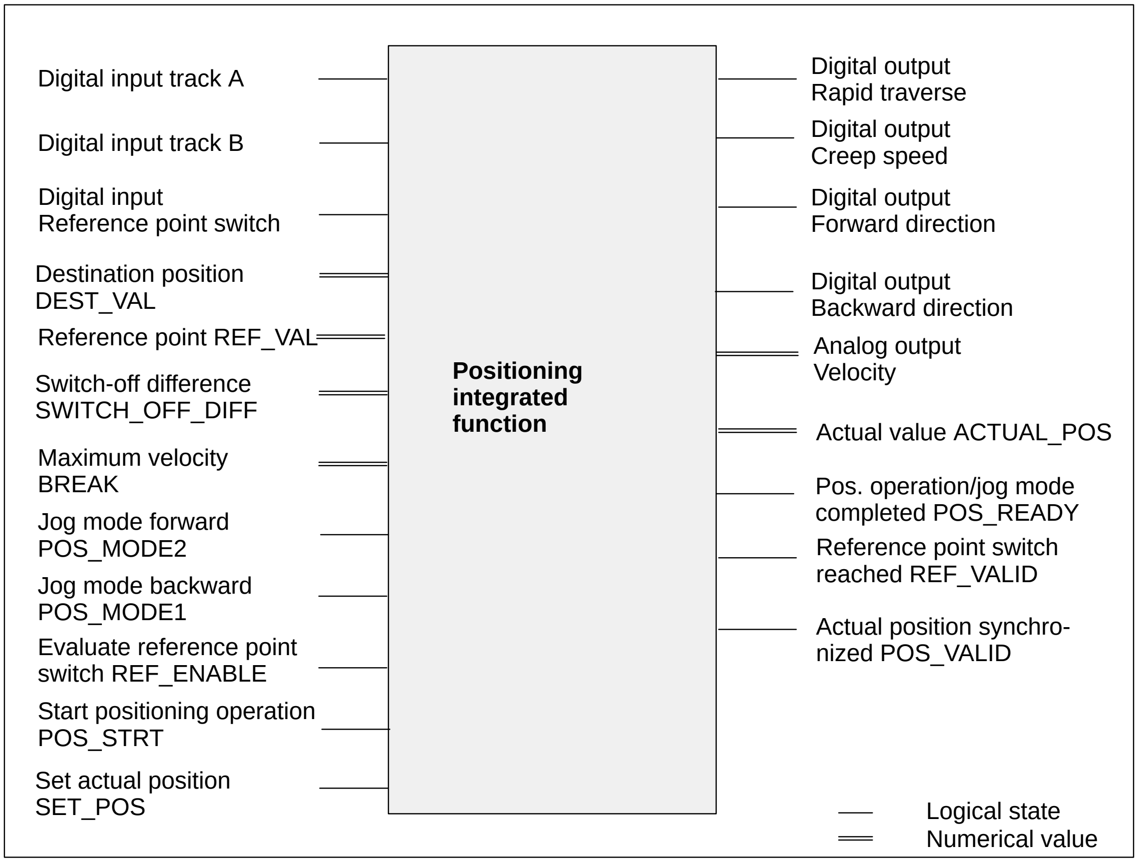

Figure 6-13 Inputs and Outputs of the Positioning Integrated Function

Overview of the Hardware Inputs/ Outputs

Table 6-3 gives an overview of the integral inputs/outputs on the CPU 314 IFM which you can wire with sensors and actuators for the Positioning integrated function.

You parameterize the function of the hardware outputs with STEP 7 (see Section 6.3).

Table 6-3 Overview of the Function of the Hardware Inputs/Outputs

Input/Output on the CPU		Function when Controlling...	
		Rapid Traverse/Creep Speed Drive	Frequency Converter
Digital input, track A Digital input, track B	I 126.0 I 126.1	Connect incremental encoders for position encoding	
Digital input, reference point switch	I 126.2	Connect reference point switch (e.g. BERO) for synchronization	
Digital output, creep speed Digital output, rapid traverse	Q 124.0 Q 124.1	Output velocities for drive	–
Digital output, backward Digital output, forward	Q 124.2 Q 124.3	Output direction of rotation for drive	If frequency converter can only process positive analog signals, specify direction of rotation for drive
Analog output, velocity	PQW 128	–	If frequency converter can process signed analog signals, specify direction of rotation for drive Specify velocity for drive

Overview of Software Inputs/ Outputs

Table 6-4 gives an overview of the software inputs and outputs of the integrated function.

The software inputs/outputs are available to you as parameters in SFB 39. You assign the parameters in your user program. You will find a detailed description of the parameters in Section 6.7.

Table 6-4 Overview of the Function of the Software Inputs/Outputs

Input/Output Parameter in SFB 39	Function
DEST_VAL	Specify destination position of the axis
REF_VAL	Specify value for a new reference point
SWITCH_OFF_DIFF	Specify switch-off difference

Table 6-4 Overview of the Function of the Software Inputs/Outputs, continued

Input/Output Parameter in SFB 39	Function
BREAK	Specify maximum velocity (max. analog value) with which positioning operation/jog mode is to be executed
POS_MODE2	Execute jog mode forward, abort jog mode/positioning operation
POS_MODE1	Execute jog mode backward, abort jog mode/positioning operation
REF_ENABLE	Reference point switch will be evaluated when next reached
POS_STRT	Start positioning operation
SET_POS	New reference point accepted as actual position
ACTUAL_POS	Output: Current actual value
POS_READY	Indicator: Positioning operation completed
REF_VALID	Indicator: Whether or not synchronization has taken place during the currently executing positioning operation/jog mode
POS_VALID	Indicator: Integrated function is synchronized with axis

Boundary frequency

The Positioning integrated function counts pulses up to a maximum frequency of 10 kHz.

Mechanical Instability

If counting pulses are initiated at tracks A and B due to mechanical instability, this can result in a loss of 1 increment in the worst case.

Exceeding the Boundary frequency

If pulse frequencies > 10 kHz occur for several milliseconds, please note the following warning:

Warning

If the boundary frequency of 10 kHz is exceeded:

- Correct functioning of the integrated function cannot be guaranteed
- Cycle load increases
- Process interrupt response time increases
- Communication interference can result (including loss of connection).

If the cycle time monitor trips, the CPU goes to STOP.

6.3 Parameter Assignment

Parameter Assignment Software

You assign parameters to the integrated function with *STEP 7*. You will find a description of how to use *STEP 7* in the User Manual *Standard Software for S7 and M7, STEP 7*.

Parameters and their Value Ranges

Table 6-5 lists the parameters for the Positioning integrated function of the CPU 314 IFM.

Table 6-5 “Positioning” Register

Parameter	Explanation	Value Range	Default Setting
Drive control via	The following are available for controlling the power section: • 4 digital outputs • 2 digital outputs and 1 analog output (0 to 10 V/0 to 20 mA) • 1 analog output ($\pm$10 V/$\pm$20 mA) Select 4 digital outputs (DQs) for rapid traverse/creep speed drive. Choose between the 2 other alternatives if you want to control a frequency converter. **Please note**: To be able to process the output analog value in the CPU, direct the analog value to an analog input and read in this value.	• 4 digital outputs (DQs) • 2 DQs + 1 AQ • 1 analog output (AQ)	4 digital outputs (DQs)
Acceleration distance to maximum velocity (= stopping distance)	You determine the distance during which: • the analog value in the case of frequency converters is output to the maximum value or reduced to “0” • traverse is executed in the case of contactor circuits at rapid traverse or creep speed	0*; 48 to 65535 increments	65535 increments
Evaluation of reference point switch by direction	You can determine the direction from which the reference point switch must be reached in order to be evaluated.	Forward Backward	Forward
Number of the instance DB	The instance DB contains the data exchanged between the integrated function and the user program.	1 to 127	59
Automatic updating at the cycle control point	You determine whether the instance DB of the integrated function is to be updated at each cycle control point or not.	Activated/deactivated	Activated

* If you specify “0” in the case of rapid traverse/creep speed drives, the system switches to creep speed for 1 increment and thereafter the digital outputs “Creep speed” and “Direction forward/backward” are set to “0”.
If you specify “0” in the case of frequency converters, the analog value will be increased by one step with each increment.

6.4 Controlling the Outputs via the Integrated Function

Controlling a Rapid Traverse/ Creep Speed Drive

You will find the velocity profile of the rapid traverse/creep speed drive and the control of the 4 digital outputs in Section 6.1.4.

Calculation of the Analog Value

Calculation of the analog value for control of the acceleration/stopping distance via a frequency converter is explained below. You will find the complete velocity profile in Section 6.1.5.

Analog Value Output in Steps

Figure 6-14 shows the analog values after the start of two positioning operations. In the enlarged view of the acceleration distances, you can see that the curves each consist of 10 steps of equal width and different height.

The analog values are therefore output in steps from the CPU. You specify the width of the steps indirectly with the acceleration/stopping distance. The height of the steps is fixed by the integrated function.

Please note the ratio of the step height to the step width and the associated traverse curve for your special application. The larger the acceleration/stopping distance you specify, the wider will be the steps.

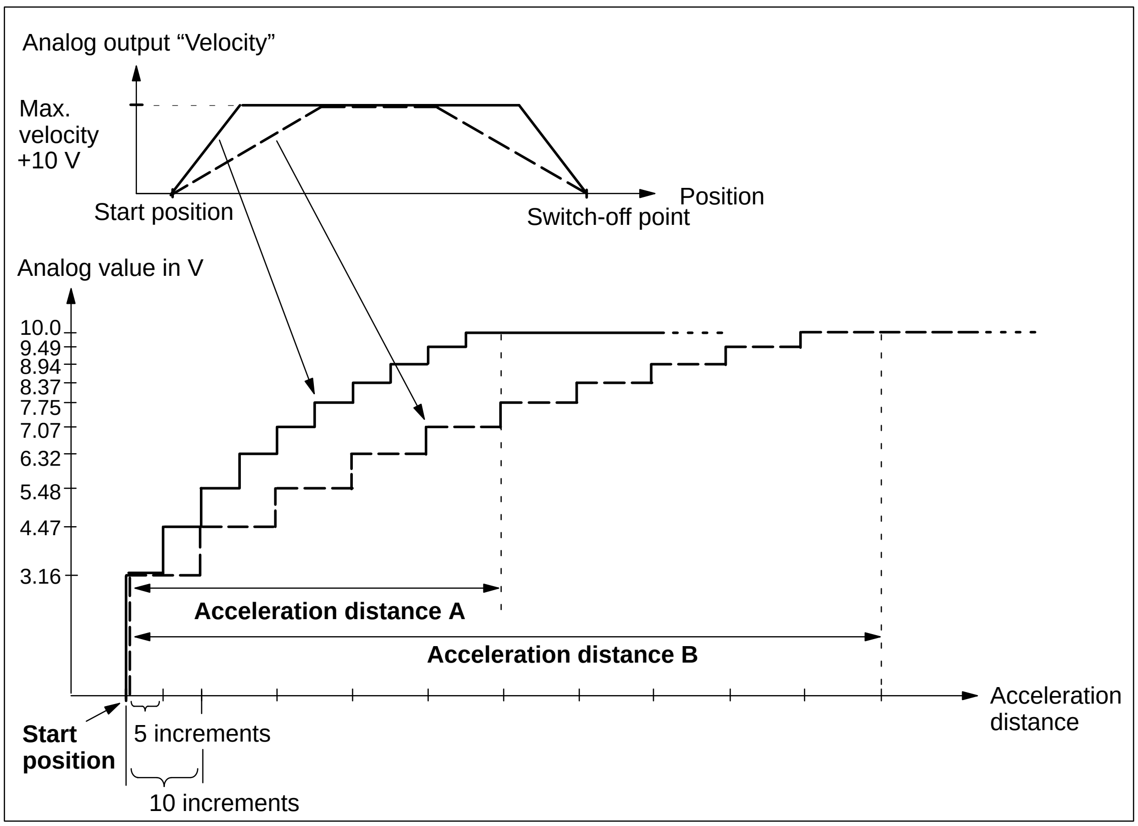

Figure 6-14 Analog Value Output in Steps, BREAK = 0

Stopping Distance

The analog values for the stopping distance are output in the same 10 steps as for the acceleration distance (see Figure 6-14). The switch-off point is reached at the end of the last step (= 3.16 V).

Calculating the Step Width

The step width is calculated by the integrated function as follows:

$$\text{Step width} = \frac{\text{Acceleration/stopping distance}}{10}$$

Please note: The calculated step width is always rounded down so that the acceleration/stopping distance actually traversed is never greater than the parameterized acceleration/stopping distance.

Example

Below are two examples of calculating the step width. The resulting analog value outputs are shown in Figure 6-14. The acceleration/stopping distances have been parameterized with *STEP 7*.

$$\text{Step width A} = \frac{\text{59 increments}}{10}$$

Step width A = 5.9 increments
≈ **5 increments**

$$\text{Step width B} = \frac{\text{105 increments}}{10}$$

Step width B = 10.5 increments
≈ **10 increments**

The calculated step widths result in acceleration/stopping distance B being twice as long as acceleration/stopping distance A.

Maximum Analog Value

The maximum analog value for controlling a frequency converter is calculated according to the following formulae:

$$v = \frac{10\ \text{V}}{256} \times (256 - \text{BREAK}) \text{ or } v = \frac{20\ \text{mA}}{256} \times (256 - \text{BREAK})$$

You specify the input parameter “BREAK” of SFB 39 in the user program (see Table 6-11).

6.5 Effect of the Distance Between the Start and Destination Position on Controlling the Outputs

Dependencies

Control of the outputs depends on the distance between the start and destination position of the axis.

Controlling a Rapid Traverse/ Creep Speed

Please note the behavior shown in Table 6-6 when defining the acceleration/ stopping distance with *STEP 7* and specifying the switch-off difference at the input parameter SWITCH_OFF_DIFF of SFB 39 for a rapid traverse/creep speed drive.

Table 6-6 Controlling Rapid Traverse/Creep Speed Drives

Contactor Circuit	Distance Between Start and Destination Position is...	Description
Digital outputs	> Acceleration/stopping distance + switch-off difference	It is started with rapid traverse (requirement: input parameter BREAK = 0).
	≤ Acceleration/stopping distance + switch-off difference > Switch-off difference	It is started with creep speed.
	≤ Switch-off difference	Does not start a positioning operation: POS_READY remains unchanged at “1”.

Controlling Frequency Converters

Please note the behavior shown in Table 6-6 when defining the acceleration/ stopping distance with *STEP 7* and specifying the switch-off difference at the input parameter SWITCH_OFF_DIFF of SFB 39 for controlling frequency converters.

Table 6-7 Controlling Frequency Converters

Frequency Converter	Distance Between Start and Destination Position is...	Description
Analog output Digital outputs	≥ 2 x acceleration/stopping distance + switch-off difference	The axis traverses the entire acceleration and stopping distance.
	< 2 x acceleration/stopping distance + switch-off difference > Switch-off difference	The axis traverses the distance to the switch-off point half as acceleration distance and half as stopping distance. The max. analog value is not reached.
	≤ Switch-off difference	Does not start a positioning operation: POS_READY remains unchanged at “1”.

Influencing the Velocity

The velocity at which the drive is controlled by the frequency converter can be influenced at the BREAK input parameter of SFB 39. SFB 39 is described in Section 6.7.

6.6 Wiring

This Section

This section describes

- How to connect the incremental encoder and the reference point switch to the integral inputs/outputs
- How to connect the different power sections to the integral inputs/outputs

In this Section

Section	Contents	Page
6.6.1	Connecting the Incremental Encoder and the Reference Point Switch to the Integral Inputs/Outputs	6-24
6.6.2	Connecting the Power Section to the Integral Inputs/Outputs	6-26

6.6.1 Connecting the Incremental Encoder and the Reference Point Switch to the Integral Inputs/Outputs

Introduction

You connect tracks A and B of the incremental encoder and the reference signal to 3 digital inputs of the CPU 314 IFM.

Evaluating the Zero Mark Signal

Most incremental encoders supply at each revolution a zero mark signal that can be used for synchronization. If you want to evaluate the zero mark signal of the incremental encoder, connect it to the reference point switch digital input (I 126.2).

You will find information on pulse evaluation via the Positioning integrated function in Appendix D.

Using Inputs for the Integrated Function

Please note the following when using the integral inputs/outputs with the Positioning integrated function:

Note

For the proper functioning of the Positioning integrated function, you must not use anywhere else the inputs of the integral inputs/outputs used by the Positioning integrated function.

Standard Inputs

You can use the special inputs not required by the Positioning integrated function as standard digital inputs. However, interrupt initiation is not possible at these inputs. (Special inputs = I 126.0 to I 126.3)

Terminals

Table 6-8 shows you the relevant terminals of the integral inputs/outputs of the CPU 314 IFM for connecting the incremental encoder and the reference point switch.

Table 6-8 Terminals for Incremental Encoders and Reference Point Switch

Terminal	Identifier	Description
2	I 126.0	Track A
3	I 126.1	Track B
4	I 126.2	Reference point switch
Connection of CPU voltage supply	L+	Supply voltage
Connection of CPU voltage supply	M	Ground

Terminal Connection Model

Figure 6-15 shows the connections to the integral inputs/outputs. A BERO is used as the reference point switch.

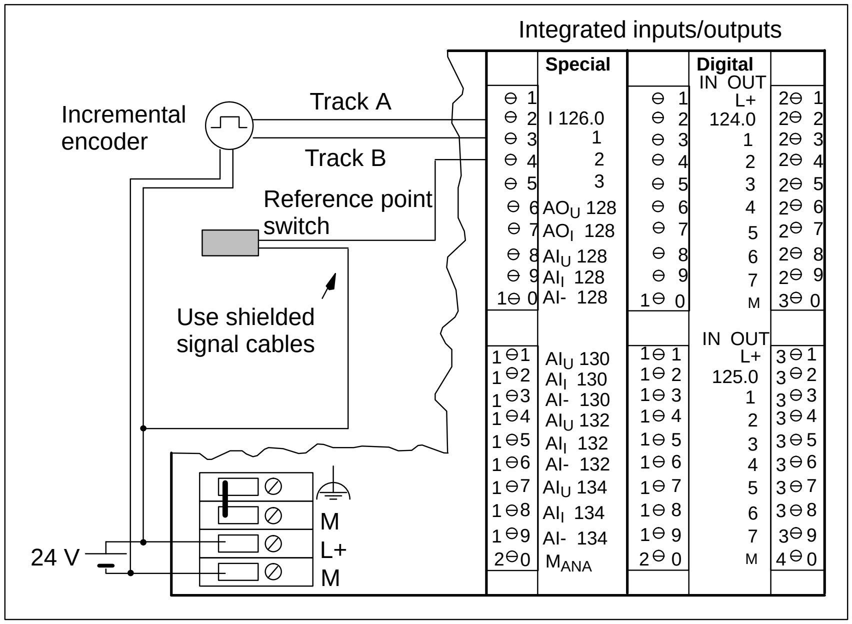

Figure 6-15 Connecting Incremental Encoder and Reference Point Switch

Shielding

You must use shielded signal cables for connecting the sensors and connect the cable shielding to ground. Use the shield connecting element for this purpose.

You will find detailed information on applying the cable shielding in the manual *S7-300 Programmable Controller, Installation and Hardware*.

6.6.2 Connecting the Power Section to the Integral Inputs/Outputs

Introduction

There are 4 digital outputs and 1 analog output available to you at the integral inputs/outputs for connecting the power section. A contactor circuit for rapid traverse/creep speed drives or a frequency converter can be used as the power section.

Enabling Outputs

If you have used *STEP 7* to parameterize the CPU for positioning, the relevant outputs of the integral inputs/outputs will be automatically enabled for the Positioning integrated function.

Using Outputs for IF

Please note the following when using the integral inputs/outputs with the Positioning integrated function:

Note

For the proper functioning of the Positioning integrated function, you must not use anywhere else the outputs of the integral inputs/outputs used by the Positioning integrated function.

Standard Outputs

You can use the outputs not required by the Positioning integrated function as standard digital outputs/analog output.

Contactor Circuit

The contactor circuit is connected to 4 digital outputs.

Terminals

Table 6-9 shows you the relevant terminals.

Table 6-9 Terminals for the Contactor Circuit

Terminal	Identifier	Description
21	L+	Supply voltage
22	Q 124.0	Creep speed digital output
23	Q 124.1	Rapid traverse digital output
24	Q 124.2	Backward direction digital output
25	Q 124.3	Forward direction digital output
30	M	Ground

Terminal Connection Model

Figure 6-16 is an example of how the contactor circuit is wired.

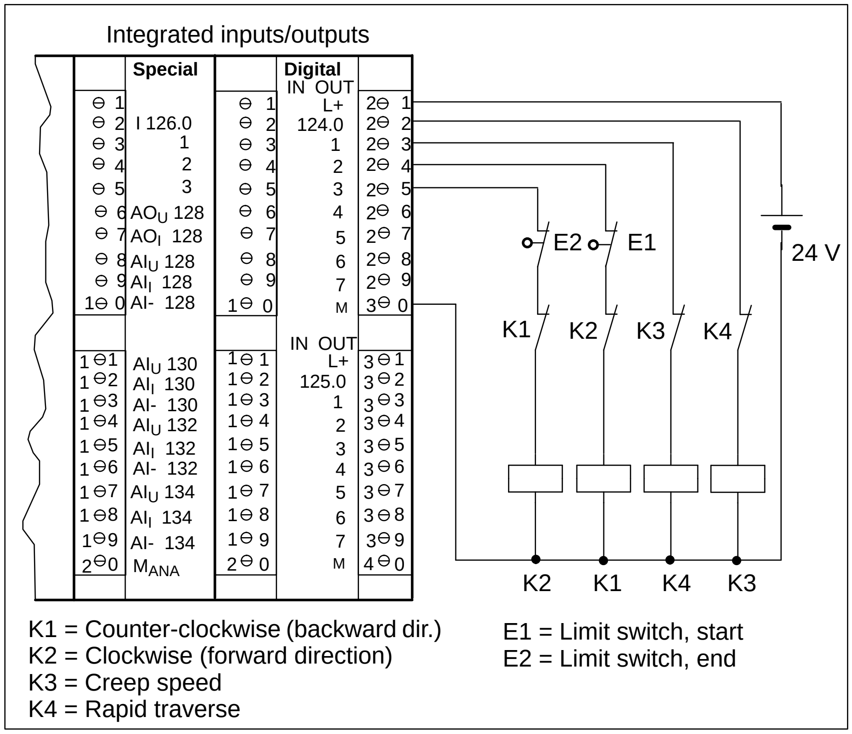

Figure 6-16 Connecting the Contactor Circuit

Description of the Contactor Circuit

Contactors K1 and K2 control clockwise and anti-clockwise rotation of the motor. Both contactors are interlocked against each other by NC contacts K1 and K2. If either of the limit switches K1 or K2 is reached, the motor switches off.

Contactors K3 and K4 switch the motor from rapid traverse to creep speed. Both contactors are interlocked against each other by NC contacts K3 and K4.

Caution

Interlock the contactors against each other as shown in Figure 6-16!

Failure to observe this regulation can lead to a short-circuit in the power network and result in the destruction of components.

Frequency Converter

If you control a frequency converter, the following outputs are connected:

- Velocity analog output (current or voltage)
  and possibly
- Forward direction and backward direction digital outputs (if the frequency converter can only process positive analog signals).

Terminals

Table 6-10 shows you the relevant terminals.

Table 6-10 Terminals for Frequency Converters

Terminal	Identifier	Description
6	AO_U 128	Velocity voltage analog output
7	AO_I 128	Velocity current analog output
20	M_{ANA}	Analog ground
24	Q 124.2	Backward direction digital output
25	Q 124.3	Forward direction digital output
30	M	Ground

Terminal Connection Model 1 Analog Output and 2 Digital Outputs

Figure 6-17 shows an example wiring a frequency converter with 1 analog output and 2 digital outputs. Control here is via the velocity current analog output.

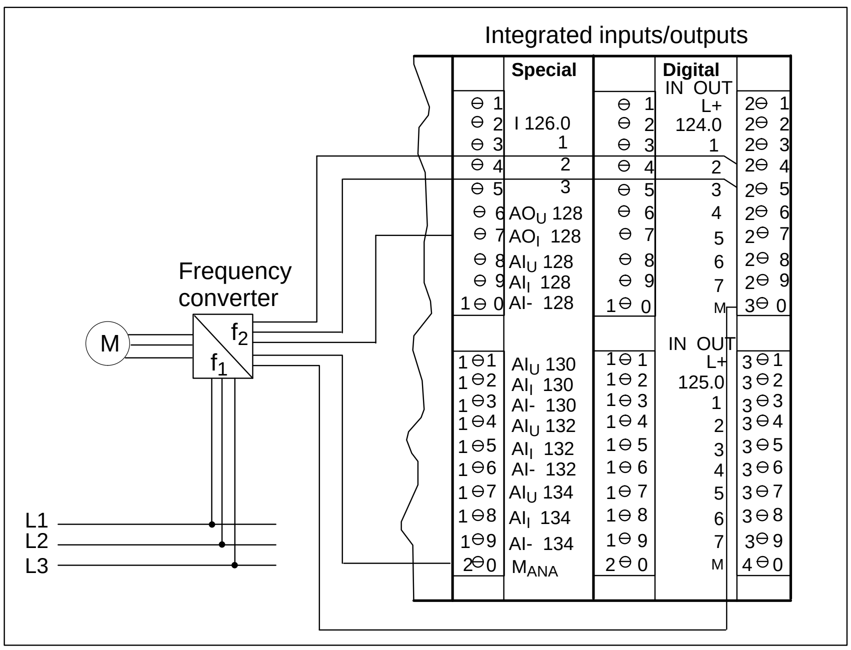

Figure 6-17 Connecting a Frequency Converter with 1 Analog Output and 2 Digital Outputs

Terminal Connection Model 1 Analog Output

Figure 6-18 shows an example wiring a frequency converter with 1 analog output. Control here is via the velocity voltage analog output.

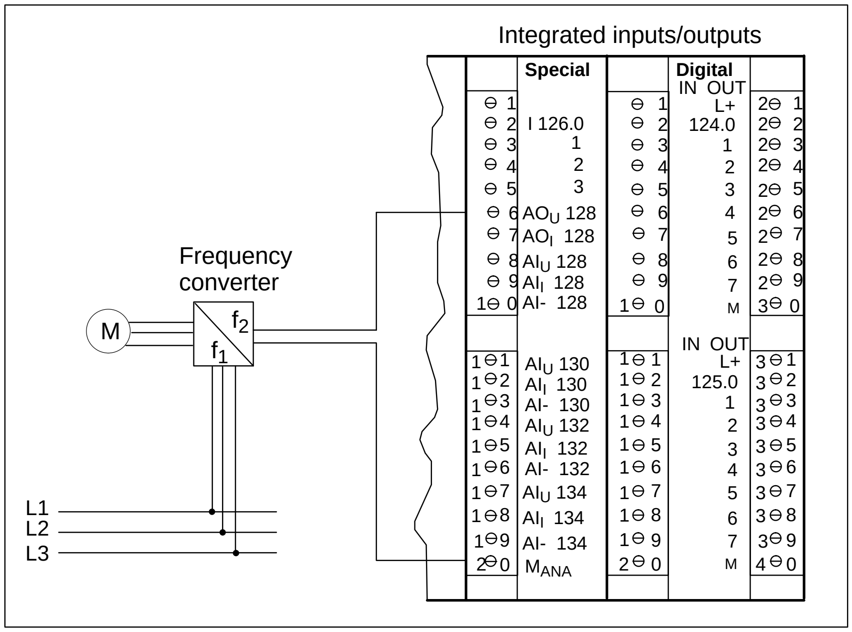

Figure 6-18 Connecting a Frequency Converter with 1 Analog Output

6.7 System Function Block 39

This Section

This section describes the structure of SFB 39, the functional principle of the input and output parameters of SFB 39 and the functionality of the Positioning integrated function.

In this Section

Structure of SFB 39

The Positioning integrated function is assigned to SFB 39. Figure 6-19 is a graphical representation of SFB 39.

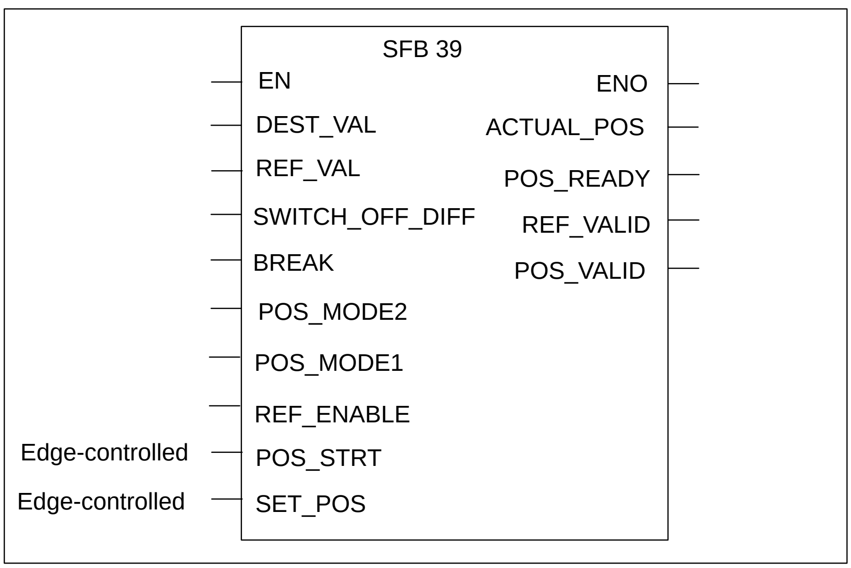

Figure 6-19 Graphical Representation of SFB 39

Input Parameters of SFB 39

Table 6-11 contains a brief description of the input parameters. The relationships between the input and output parameters are explained in more detail in the sections following this.

Table 6-11 Input Parameters of SFB 39

Input Parameter	Description
EN	EN is the enable input of SFB 39. This enable input causes the SFB to be executed. The SFB is executed as long as EN=1. When EN=0, the SFB is not executed.
DEST_VAL	The destination position approached by the Positioning integrated function is stored at this input parameter. **Caution** In the synchronized state, the traverse range must be within the value range. **The limits of the value range are not monitored**. In the event of an overflow, counting continues with the smallest or greatest value in the value range. Data type: DINT Address ID: I,Q,M,L,D Value range: from –2147483648 to 2147483647
REF_VAL	You can store a new reference point at this input parameter. The reference point is accepted at synchronization (see Section 6.7.1). Data type: DINT Address ID: I,Q,M,L,D Value range: from –2147483648 to 2147483647
SWITCH_OFF_DIFF	You determine the switch-off difference (difference between the switch-off point and the destination position) in distance increments at this input parameter. Data type: WORD Address ID: I,Q,M,L,D Value range: from 0 to 65535
BREAK	With this input parameter, you specify the maximum analog value with which a traverse movement can be controlled. The maximum analog value determines the maximum velocity of the traverse. **The following applies when controlling a frequency converter:** $v = \frac{10\ V}{256} \times (256 - BREAK)$ or $v = \frac{20\ mA}{256} \times (256 - BREAK)$ The maximum analog value you can specify is 10 V or 20 mA, that is, BREAK = 0. **The following applies when controlling a contactor circuit:** If BREAK = 0, traverse is carried out at rapid traverse and creep speed. IF BREAK 0, traverse is only at creep speed. Data type: BYTE Address ID: I,Q,M,L,D Value range: from 0 to 254
POS_MODE1, POS_MODE2	Jog mode is started and executed by combining POS_MODE1, POS_MODE2 and POS_STRT (see Section 6.7.2). Data type: BOOL Address ID: I,Q,M,L,D Value range: 0/1 (FALSE/TRUE)
REF_ENABLE	This input parameter is used for selecting and enabling synchronization per hardware (see Section 6.7.1). Data type: BOOL Address ID: I,Q,M,L,D Value range: 0/1 (FALSE/TRUE)
POS_STRT	The positioning operation is started following a rising edge at this input parameter (see Section 6.7.3). Data type: BOOL Address ID: I,Q,M,L,D Value range: 0/1 (FALSE/TRUE)
SET_POS	Following a rising edge at this input parameter, the value at the REF_VAL input parameter is accepted as the new actual value by the integrated function (synchronization per software; see Section 6.7.1). Data type: BOOL Address ID: I,Q,M,L,D Value range: 0/1 (FALSE/TRUE)

Output Parameters of SFB 39

Table 6-12 contains a brief description of the output parameters of SFB 39. The relationships between the input and output parameters are explained in the sections following this.

Please note: If the start position of the axis is in immediate proximity to a reference point or a switch-off point, inconsistencies between the indicated actual value and the status signals of the integrated function can result before the next increment is received.

Table 6-12 Output Parameters of SFB 39

Output Parameter	Description
ENO	The ENO output parameter indicates whether an error has occurred during execution of SFB 39. IF ENO=1, no error has occurred. IF ENO=0, SFB 39 has not been executed or an error occurred during execution (see Appendix E).
ACTUAL_POS	The current actual position is continuously output at this output parameter. Data type: DINT Address ID: I,Q,M,L,D Value range: from –2147483648 to 2147483647
POS_READY (status signal)	This output parameter indicates whether the positioning operation or jog mode are running. If the positioning operation/jog mode has been completed (POS_READY = 1), a new positioning operation can be started. The positioning operation/jog mode is considered completed when the switch-off point has been reached or the positioning operation/jog mode has been aborted. **Caution** There is no guarantee that the axis is stopped if POS_READY = 1. Data type: BOOL Address ID: I,Q,M,L,D Value range: 0/1 (FALSE/TRUE)
REF_VALID (status signal)	This output parameter indicates whether the reference point switch has been reached or not. It is set when hardware synchronization has taken place. Data type: BOOL Address ID: I,Q,M,L,D Value range: 0/1 (FALSE/TRUE)
POS_VALID (status signal)	This output parameter indicates whether the actual position of the axis has been synchronized with the actual value of the integrated function. If the signal state is 0, synchronization has not taken place. The positioning operation cannot be started and only jog mode is possible. Data type: BOOL Address ID: I,Q,M,L,D Value range: 0/1 (FALSE/TRUE)

CPU Operating State Transitions

See Section 6.7.4 for the states of the input and output parameters of SFB 39 in the case of CPU operating state transitions.

6.7.1 Synchronization

Two Synchronization Methods

The following synchronization methods are available for the integrated function:

- Software synchronization via the SET_POS input parameter of SFB 39
- Hardware synchronization via evaluation of the reference point switch digital input I 126.2 via the integrated function.

Software Synchronization

A new reference point is stored via the REF_VAL input parameter at SFB 39. This reference point is accepted as the actual value if:

- POS_READY = 1 and
- a rising edge occurs at SET_POS

The POS_VALID (synchronization has taken place) output parameter is also set.

Please note: If SET_POS = 1 is set when POS_READY = 0, synchronization does not take place. Synchronization also does not take place if POS_READY changes back to “1”.

Note

If other edges at input parameters of SFB 39 occur simultaneously with SET_POS, these edges will not be evaluated by the integrated function until the next time the SFB is executed or at the next cycle control point(if updating of the instance DB at the cycle control point has been parameterized using *STEP 7*).

Hardware Synchronization

A new reference point is stored via the REF_VAL input parameter in SFB 39. This reference point is accepted as the actual value if:

- REF_ENABLE = 1
- Signal state at I 126.2 changes from ”0” to ”1”
- The actual direction agrees with the direction parameterized in *STEP 7* when the next counting pulse is evaluated (see Table 6-5).

The POS_VALID (synchronization has taken place) and REF_VALID (reference point switch reached) output parameters are set to “1”.

Synchronization, 2 Cases

Figure 6-20 shows 2 cases where synchronization takes place:

- Case 1: Start synchronization via REF_ENABLE input parameter
- Case 2: Start synchronization by starting jog mode (of the positioning operation)

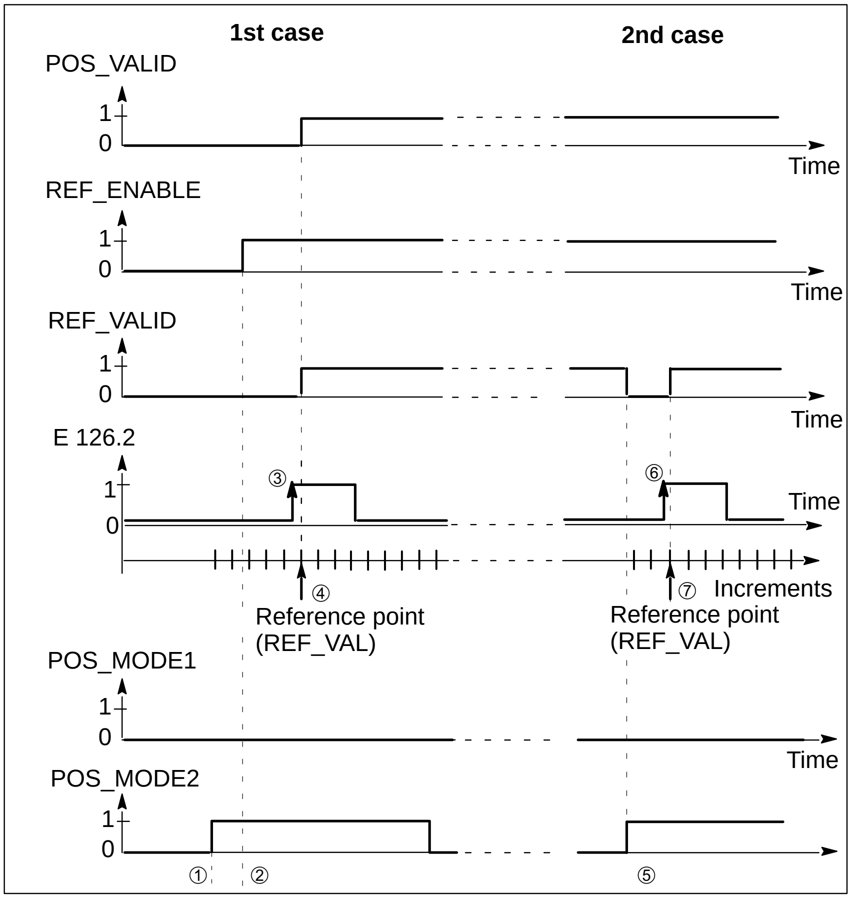

Figure 6-20 Starting Synchronization

Explanation

Table 6-13 contains the explanatory notes on Figure 6-20.

Table 6-13 Starting Synchronization

Case	Time	Event
Case 1: Start synchro-nization via REF_ENABLE	①	Jog mode forward is started via POS_MODE2.
	②	The signal state at REF_ENABLE changes from “0” to “1”: REF_VALID = 0.
	③	A rising edge occurs at the input of the reference point switch I 126.2.
	④	The new reference point at REF_VAL is accepted by the integrated function as the new actual value (synchronization takes place if this requirement is met: Parame-terized direction agrees with actual direction). POS_VALID and REF_VALID are set.
Case 2: Start synchro-nization via starting Jog Mode	⑤	POS_VALID and REF_ENABLE have signal state “1”. Jog mode forward is re-started via POS_MODE2. REF_VALID = 0.
	⑥	A rising edge occurs at the input of the reference point switch I 126.2.
	⑦	The new reference point at REF_VAL is accepted by the integrated function as the new actual value (synchronization takes place if this requirement is met: Parame-terized direction agrees with actual direction). REF_VALID is set.

Synchronization Does Not Take Place

Although REF_ENABLE = 1 and an edge occurs at I 126.2, synchronization does not take place.

Reason: If the 1st pulse at I 126.0 is detected against the parameterized direction, synchronization does not take place. The edge at I 126.2 is no longer used. That is, even if the 2nd pulse is detected in the parameterized direction, synchronization does not take place.

Resynchronization

Resynchronization to a new reference point is possible during a positioning operation or jog mode if the REF_ENABLE input parameter changes to “1” and the traversing direction is maintained. The reference point becomes valid as the new actual value when reference point switch I 126.2 is reached.

This means that a new destination position is approached that is located on the axis, offset to the old destination position by the difference between the new and old actual value.

Note

If a positioning operation/jog mode is started with REF_ENABLE = 1, REF_VALID is set to “0”. If the instance DB is not updated between reaching the reference point and starting the next positioning operation/jog mode, REF_VALID is not set to “1” although correct synchronization has taken place.

Synchronization/ Resynchronization

Figure 6-21 illustrates synchronization with later resynchronization.

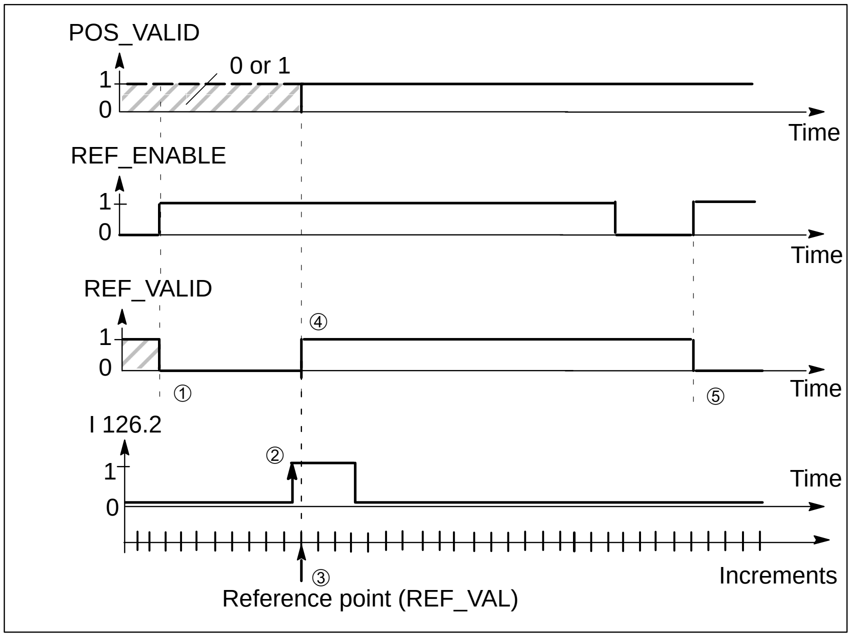

Figure 6-21 Hardware Synchronization and Resynchronization

Explanatory Notes on Figure 6-21

Table 6-14 contains explanatory notes on Figure 6-21.

Table 6-14 Hardware Synchronization and Resynchronization

Time	Event
①	Regardless of whether synchronization has taken place or not (POS_VALID = 0 or 1), REF_ENABLE is set to “1”. If REF_VALID is set, it will be reset.
②	A rising edge occurs at the input of the reference point switch I 126.2.
③	The new reference point at REF_VAL is accepted as the new actual value by the integrated function (synchronization takes place if this requirement is met: Parameterized direction agrees with actual direction). POS_VALID is set if not already set. REF_VALID is set.
④	If resynchronization is to take place, you must evaluate REF_VALID. REF_VALID must have signal state “1”.
⑤	If REF_ENABLE changes again from “0” to “1”, REF_VALID is reset and resynchronized to a new reference point REF_VAL after the next edge at I 126.2 (see ② and ③).

Special Cases with Frequency Converters

Table 6-15 lists the special cases which can occur when controlling a frequency converter.

Table 6-15 Special Cases During Synchronization (Frequency Converter)

Special Case	Explanation
New switch-off point has already been passed	If, during synchronization, the integrated function detects that the new switch-off point has already been passed, all remaining steps of the analog value are output at intervals of 1 increment until analog value “0” is reached.
New reference point is within stopping distance	If, during synchronization, the integrated function detects that the new reference point is within the stopping distance of the positioning operation/jog mode, all steps of the analog value are output at intervals of 1 increment until the currently valid value is reached.
Synchronization takes place within acceleration distance	If the positioning operation/jog mode is within the acceleration distance during synchronization, all steps of the analog value are output until the currently valid value is reached. If necessary, • the analog value will be output at intervals of 1 increment until the highest step is reached and then the stopping distance is started. • the acceleration distance/stopping distance will be increased.

Special Cases with Contactor Circuit

Table 6-16 lists special cases which can occur when controlling a contactor circuit.

Table 6-16 Special Cases During Synchronization (Contactor Circuit)

Special Case	Explanation
New switch-off point has already been passed	If, during synchronization, the integrated function detects that the new switch-off point has already been passed, traverse is continued for 1 increment at creep speed and then switched off.
New reference point is within stopping distance	If, during synchronization, the integrated function detects that the new reference point is within the stopping distance of the current positioning operation/jog mode, traverse is continued at creep speed until the switch-off point is reached.

Caution

If the special cases shown in Tables 6-15 and 6-16 cause impermissible or unforeseeable operating states of the axis, you must ensure there is no destination position or acceleration/stopping distance in the area of the reference point switch I 126.2.

6.7.2 Execute Jog Mode

Jog Mode

Jog mode corresponds to a positioning operation in the value range – 2147483648 to 2147483647 increments.

Please Note

Jog mode is only started if the actual value is at the following interval to the lower or upper limit of the value range given above:

- ≥ 2 x acceleration distance or stopping distance in the case of frequency converters
- > stopping distance in the case of a contactor circuit.

After a CPU STOP-RUN transition, the instantaneous actual value is taken from the instance DB. If this actual value is so close to one of the value range limits that jog mode cannot be started, you specify a new actual value with a rising edge at SET_POS to be able to then start jog mode.

Selecting Jog Mode

Table 6-17 explains how to combine the input and output parameters for selecting/terminating jog mode.
Please note: Input parameter combinations other than those listed in Tables 6-17 and 6-18 are ignored.

Table 6-17 Selecting Jog Mode

Jog Mode	Input/Output Parameter	Description
Jog mode forward*	Requirement: POS_READY = 1 POS_MODE1 = 0 POS_MODE2 = 1 POS_STRT = 0	Jog mode forward is started and POS_READY is reset (see Figure 6-22).
Jog mode backward*	Requirement: POS_READY = 1 POS_MODE1 = 1 POS_MODE2 = 0 POS_STRT = 0	Jog mode backward is started and POS_READY is reset.
Terminate jog mode	POS_MODE1 = 0 POS_MODE2 = 0	Jog mode is terminated. POS_READY is then set to “1” (See Figure 6-22).
Terminate jog mode and start in opposite direction	Change previous signal states of POS_MODE1 and POS_MODE2 POS_STRT = 0	Jog mode is terminated. POS_READY is then set to “1”. After POS_READY has been set to “1”, jog mode is started in the opposite direction at the next SFB call or at the next cycle control point.
Abort jog mode	POS_MODE1 = 1 POS_MODE2 = 1	The currently running jog mode is aborted immediately. POS_READY is set to “1” (see Figure 6-22).

* If you set POS_MODE1 or 2 when POS_READY = 0, jog mode will not be started. It will also not be started if POS_READY = 1. Remedy: Reset POS_MODE1 or 2 back to “0” and start jog mode again as soon as POS_READY = 1.

Terminating Jog Mode

For frequency converters, terminating means:

- jog mode is terminated normally via the stopping distance to the switch-off point.

  For contactor circuits, terminating means:

- jog mode is terminated normally via creep speed to the switch-off point.

Aborting Jog Mode

Both for frequency converters and for contactor circuits, “Abort jog mode” means that all outputs are immediately set to “0”. The traverse is not continued to the switch-off point to terminate jog mode. Jog mode can only be restarted after POS_MODE1 = 0 and POS_MODE2 = 0 has been specified.

Jog Mode Examples

Figure 6-22 shows jog mode forward, terminating jog mode and aborting jog mode using a contactor circuit example.

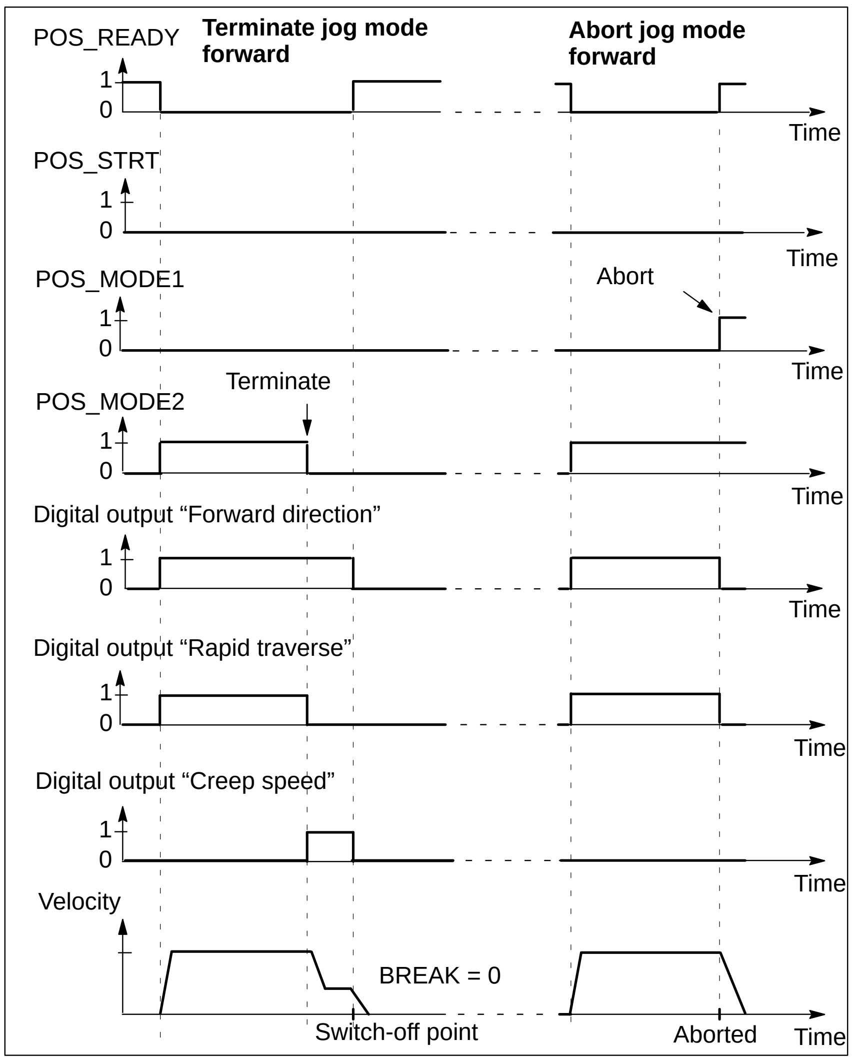

Figure 6-22 Jog Mode Forward and Terminating/Aborting Jog Mode

6.7.3 Executing a Positioning Operation

Executing a Positioning Operation

Figure 6-18 explains how to combine the input and output parameters for selecting/terminating a positioning operation.
Please note: Input parameter combinations other than those listed in Tables 6-17 and 6-18 are ignored.

Table 6-18 Executing a Positioning Operation

Positioning Operation	Input/Output Parameter	Description
Start positioning operation*	Requirement: POS_READY = 1 Rising edge at POS_STRT POS_MODE1 = 0 POS_MODE2 = 0	The positioning operation is started with the rising edge at POS_STRT. The destination position specified at DEST_VAL is accepted and POS_READY is reset.
Positioning operation running	POS_STRT = 1	The positioning operation is running and terminates itself when the switch-off point is reached. POS_READY is set to “1”.
Terminate positioning operation prematurely	Falling edge at POS_STRT	The positioning operation is terminated prematurely. POS_READY is then set to “1”.
Abort positioning operation*	POS_MODE1 = 1 POS_MODE2 = 1	The currently running positioning operation is aborted. POS_READY is set to “1”.

* If the input parameters POS_MODE1/POS_MODE2 are set, you must reset them to “0” before they can be evaluated again by the integrated function.

Terminating the Positioning Operation

For frequency converters, terminating means:

- The positioning operation is terminated normally via the stopping distance to the switch-off point.

  For contactor circuits, terminating means:

- The positioning operation is terminated normally via creep speed to the switch-off point.

Aborting the Positioning Operation

Both for frequency converters and for contactor circuits, “Abort positioning operation” means that all outputs are immediately set to “0”. The traverse is not continued to the switch-off point to terminate the positioning operation.

Explanatory Notes on Figure 6-23

Table 6-19 contains explanatory notes on Figure 6-23.

Table 6-19 Positioning Operation for Rapid Traverse/Creep Speed Drive

Time	Event
①	POS_MODE1 and POS_MODE2 have signal state “0”. The positioning operation is started by a rising edge at POS_STRT. POS_READY (previous positioning operation terminated) is simultaneously reset.
②	The integrated function switches to creep speed for the stopping distance.
③	The switch-off point is reached. This terminates the positioning operation. This is indicated with POS_READY = 1.

Positioning Operation Example

Figure 6-23 shows an example of a positioning operation over time. A positioning operation is started and a destination position is approached with a rapid traverse/creep speed drive.

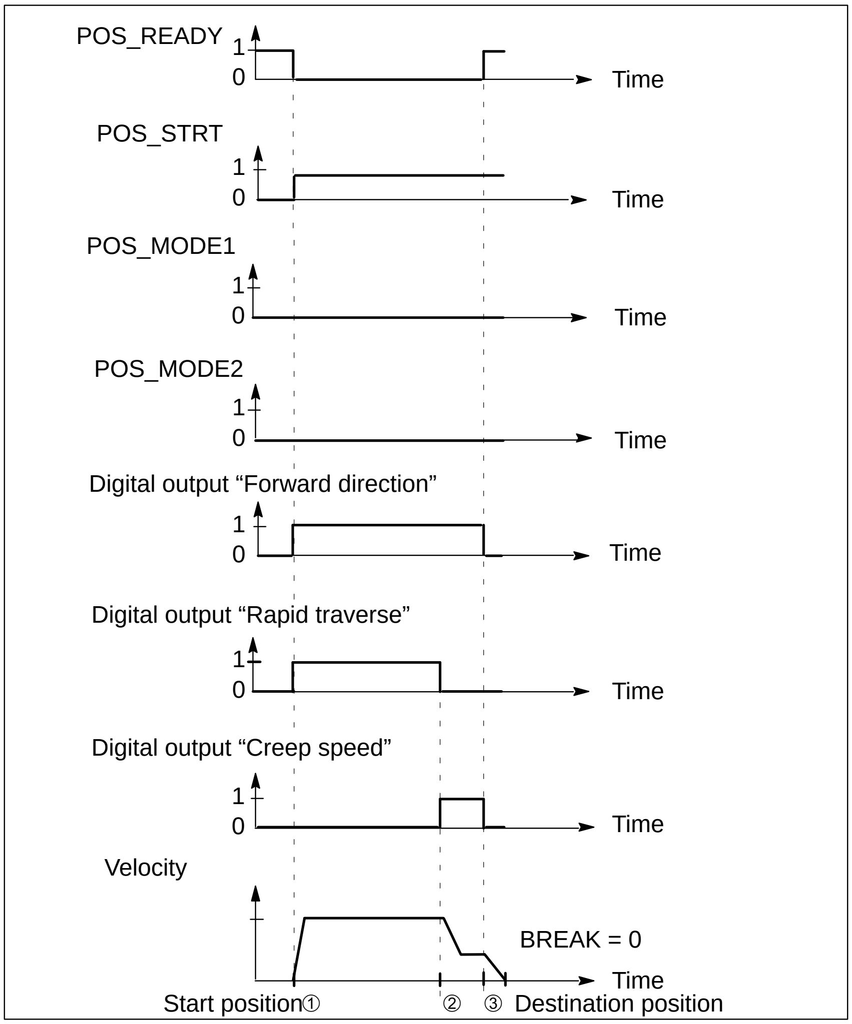

Figure 6-23 Positioning Operation for Rapid Traverse/Creep Speed Drive Forward

6.7.4 Behavior of the Input and Output Parameters of SFB 39 at CPU Operating State Transitions

STOP Operating State

If the CPU 314 IFM is in the STOP mode, the integrated function is not active.

Operating State Change

Table 6-20 describes the input/output parameter states that occur depending on the change of operating state.

Section 2.6 contains further information on the behavior of the integrated function in the different CPU operating states.

Table 6-20 Effects of a Change in CPU Operating State on the Integrated Function

CPU Operating State	Input/Output Parameter State	Description
STOP → RUN	ACTUAL_POS is not affected POS_VALID = 0 REF_VALID = 0 POS_READY = 1	currently being output The integrated function is not synchronized and must be synchronized before a positioning operation can be started (see Section 6.7.1).
RUN → STOP	SET_POS = 0 POS_STRT = 0	No new reference point is accepted as the actual position. Positioning operation not executed.
RUN → STOP → RUN	Consequences from the above-mentioned state of the parameters at → RUN and RUN → STOP transition: REF_ENABLE not affected POS_MODE_1 not affected POS_MODE_2 not affected	The state prior to CPU changing to STOP is accepted, e.g.: • if REF_ENABLE was = 1, hardware synchronization is possible • if jog mode had been selected, jog mode will be started **Remedy:** Initialize REF_ENABLE; POS_MODE1 and POS_MODE2 in OB 100 with “0” (“0” = FALSE).

6.8 Structure of the Instance DB

Instance DB of SFB 39

Table 6-21 shows you the structure and assignments of the instance DB of the Positioning integrated function.

Table 6-21 Instance DB of SFB 39

Operand	Symbol	Meaning
DBD 0	DEST_VAL	Destination position
DBD 4	REF_VAL	Reference point
DBW 8.0	SWITCH_OFF_DIFF	Switch-off difference
DBB 10	BREAK	Maximum velocity (max. analog value)
DBX 11.0	POS_MODE2	Jog mode forward
DBX 11.1	POS_MODE1	Jog mode backward
DBX 11.2	REF_ENABLE	Evaluate reference point switch
DBX 11.3	POS_STRT	Start positioning operation
DBX 11.4	SET_POS	Set actual value
DBD 12	ACTUAL_POS	Actual position
DBX 16.0	POS_READY	Positioning operation/jog mode terminated
DBX 16.1	REF_VALID	Reference point switch has been reached
DBX 16.2	POS_VALID	Synchronization has taken place
DBX 16.4 to 16.7	–	Reserved internally

Length of the Instance DB

The data for the Positioning integrated function are 18 bytes long and begin with address 0 in the instance DB.

6.9 Calculating the Cycle Time

Introduction

Calculation of the cycle time for the CPU 314 IFM is described in detail in the manual *S7-300 Programmable Controller, Installation and Hardware*. Here, we also list those times that must be included in the calculation when the Positioning integrated function is running.

Calculation

You can calculate the cycle time according to the following formula:

Cycle time = $t_1 + t_2 + t_3 + t_4$

t_1 = Process image transfer time (PII and PIQ)[1]

t_2 = Operating system runtime including onloading resulting from integrated function[2]

t_3 = User program execution time including SFB runtime if SFB call occurs in the program cycle[3]

t_4 = Updating time of the instance DB at the cycle control point (if updating has been parameterized in *STEP 7*).

SFB 39 Runtime

The runtime of the SFB is typically 150 μs.

Updating the Instance DB

The updating time of the instance DB at the cycle control point is typically 100 μs for the Positioning integrated function.

Increase in Cycle Time

Please note that the cycle time can increase as a result of:

- Time-controlled execution
- Interrupt processing
- Diagnostics and error processing

1 See the manual *S7-300 Programmable Controller, Installation and Hardware* for the time for the CPU 314 IFM.

2 You must calculate the user program execution time since it depends on your user program. **Please note**: At the boundary frequency of 10 kHz, the execution of the user program can increase by approximately 10%.

3 If the SFB is called several times in a program cycle, you must multiply the execution time of the SFB by the number of calls.

6.10 Application Examples

This Section

This section contains 3 application examples of the Positioning integrated function. The examples are the following practice-oriented applications:

- Cutting foil to length with synchronization to the workpiece start at the cutter
- Positioning cans of paint on a conveyor belt with synchronization to the workpiece start by a BERO
- Positioning a worktable with synchronization at a reference point switch in jog mode

In this Section

6.10.1 Cutting Foil to Length

Task

An endless roll of foil is to be cut into lengths of 2 m.

An incremental encoder detects the distance between the start of the foil and the current actual position.

The foil is stopped for machining, that is, for cutting. The drive is controlled depending on the current actual position.

Installing New Roll; Correcting Faults

If a new roll is installed, the start of the foil may be irregular; if machine faults have occurred during operation, the foil may be damaged. In such cases, jog mode is used.

The foil is rolled off by the operator via the user program until the irregular foil start is behind the cutter. The foil is then cut and reference point 0 is taken by the integrated function as the new actual value.

The positioning operation is then started via the user program.

Wiring

Figure 6-24 shows the technology schematic and the wiring of the example. The power section is a frequency converter with an analog output ± 10 V for direction and velocity.

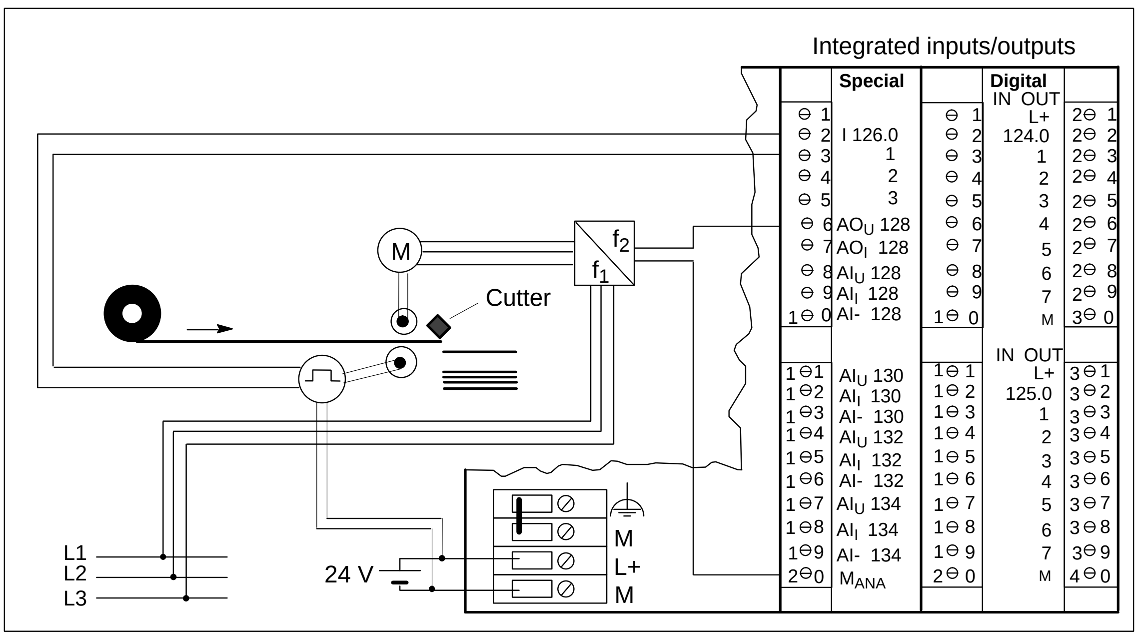

Figure 6-24 Cutting Foil to Length

Function of the Inputs and Outputs

Table 6-22 lists the functions of the inputs and outputs for the example.

Table 6-22 Switching the Inputs and Outputs (Example 1)

Terminal	Input/ Output	Function in the Example
2	I 126.0	Encoder track A
3	I 126.1	Encoder track B
6	AO_U 128	Analog output velocity voltage
20	M_{ANA}	Analog ground
Connection of voltage supply to the CPU	L+	Supply voltage
Connection of voltage supply to the CPU	M	Ground

Assigning mm Distance to Pulses (Distance Increments)

The incremental encoder supplies 100 pulses per revolution. 1 revolution of the incremental encoder corresponds to 5 revolutions of the motor. The incremental encoder therefore supplies 20 pulses per motor revolution. The foil moves 4 mm per motor revolution.

4 mm : 20 pulses = 0.2 mm

One pulse is accordingly assigned a distance of 0.2 mm. 1 pulse corresponds to 1 distance increment.

In Figure 6-25, you can see the distances/pulses assignment within a positioning operation. The foil is cut to lengths of 2 m. Conversion of mm to pulses (distance increments) is as follows:

2000 mm: 0.2 mm = 10000 pulses (distance increments)

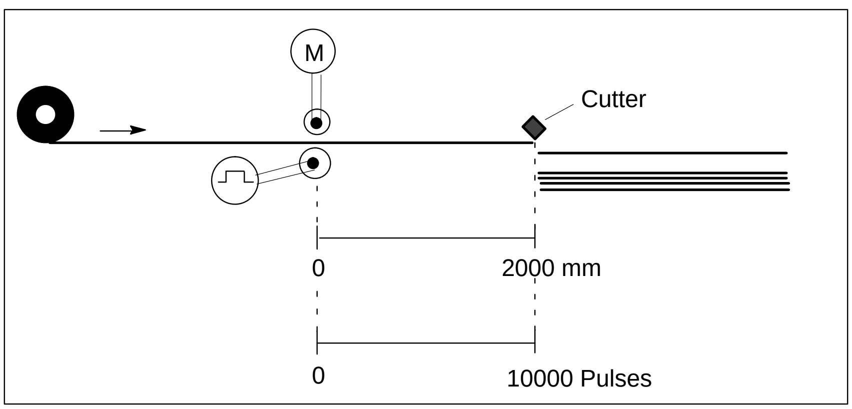

Figure 6-25 Assignment of Distances/Pulses

Distance to be Covered

You specify the destination position of **10000** pulses (distance increments) to SFB 39.

Maximum Velocity

The foil consists of tear-resistant material so there is a maximum analog value of 10 V at the analog output (V = 10). Specify BREAK = 0 at SFB 39 according to the following equation.

$$v = \frac{10\text{ V}}{256} \times (256 - \text{BREAK}) \text{ or } \text{BREAK} = 256 \times (1 - \frac{v}{10\text{ V}})$$

Determining the Acceleration/ Stopping Distance

You must parameterize the distance to be traversed from the start of the positioning operation until the maximum velocity is reached.

The maximum velocity is to be reached after 0.1 m. Conversion from mm to pulses is as follows:

100 mm: 0.2 mm = **500** pulses (distance increments) = Acceleration/stopping distance

Parameterizing with *STEP 7*

You parameterize the CPU with *STEP 7* as follows:

Table 6-23 Parameters for Cutting Foil to Length

Parameter	Input	Explanation
Electrical characteristics	1 analog output (AQ)	The motor is driven via a frequency converter with one analog output ± 10 V for direction and velocity.
Acceleration distance to maximum velocity (= stopping distance)	500	You define the distance in distance increments in which the analog value is output to the maximum value or reduced to “0”.
Evaluation of the reference point switch for direction	Forward direction	The reference point switch is evaluated when it is reached in the forward direction.
Number of the instance DB	59	Instance DB for the example (default value)
Automatic updating at the cycle control point	Activated	The instance DB us updated at each cycle control point.

Determining the Switch-Off Difference

To ensure that the destination position is reached as accurately as possible, you must:

1. Specify switch-off difference 0 to SFB 39 via the user program
2. Move the foil once via the Positioning integrated function
3. Measure the difference between the actual destination position reached and the specified destination position
4. Specify this difference as the switch-off difference in increments to SFB 39

Instance DB of SFB 39

In the example, the data are stored in instance DB 59.

Initialization of SFB 39

Figure 6-26 shows SFB 39 with initialized parameters from DB 10.

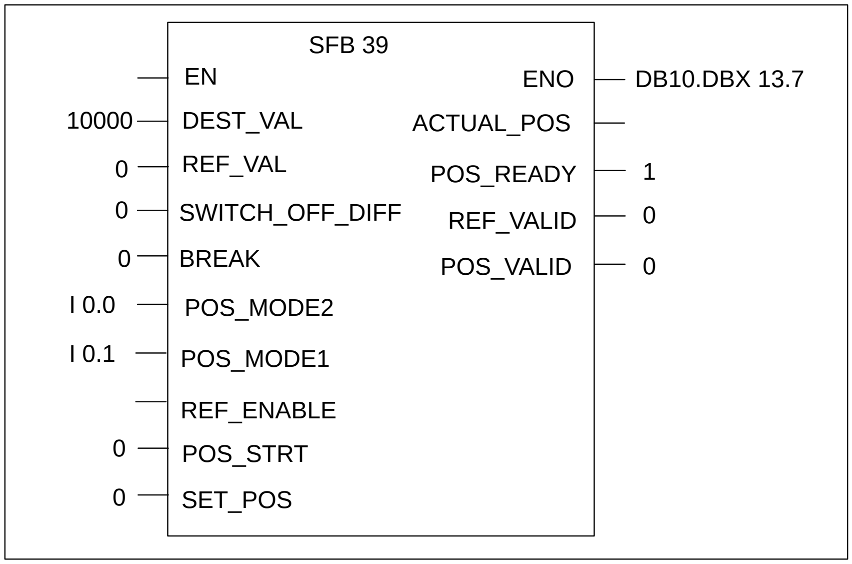

Figure 6-26 Initialization of SFB 39 on Start-Up (1)

User Program

Below is the user program for the example. It has been created with the *STL Editor in STEP 7*.

DB 10

The data for SFB 39 are stored in DB 10. The DB has the following structure:

Table 6-24 Example 1: Positioning, DB 10 Structure

Address	Name	Type	Starting value	Comment
0.0		STRUCT		
+0.0	DEST_VAL	DINT	L#10000	Destination position: Length of the foil = 2 m
+4.0	REF_VAL	DINT	L#0	Reference point = 0
+8.0	SWITCH_OFF_DIFF	INT	0	Switch-off difference (calculated at startup)
+10.0	Break	BYTE	B#16#0	Maximum velocity = 10 V
+11.0	---	BYTE	B#16#0	Unused
+12.0	Control byte	BYTE	B#16#0	Control bits for positioning
+13.0	Checkback byte	BYTE	B#16#0	Checkback status bits from positioning
=14.0		END_STRUCT		

Statement Section OB 1

You enter the following user program in the statement section of OB 1:

```
STL (OB 1)                                Explanation
Network 1
   ---------------------------------
   Call positioning
   ---------------------------------
       CALL  SFB   39 , DB59
        DEST_VAL       :=DB10.DBD0        Destination position (foil length = 2 m)
        REF_VAL        :=DB10.DBD4        Reference point (foil start)
        SWITCH_OFF_DIFF:=DB10.DBW8        Switch-off difference
        BREAK          :=DB10.DBB10       Maximum velocity
        POS_MODE2      :=DB10.DBX12.0     Jog mode forward
        POS_MODE1      :=DB10.DBX12.1     Jog mode backward
        REF_ENABLE     :=
        POS_STRT       :=DB10.DBX12.2     Start positioning operation
        SET_POS        :=DB10.DBX12.3     Control signal: Accept REF_VAL as new actual
        ACTUAL_POS     :=                 value
        POS_READY      :=DB10.DBX13.0     Checkback signal: Pos. oper./jog mode running
        REF_VALID      :=DB10.DBX13.1     Checkback signal: Ref. point switch reached
        POS_VALID      :=DB10.DBX13.2     Checkback signal: Synchron. has taken place
       A     BR                           Scanning the BR bit  (= ENO at SFB 39) for
       =     DB10.DBX   13.7              error evaluation
   ---------------------------------
   Setting up the foil
   ---------------------------------
       A     DB10.DBX   12.4              During job execution: Cut foil? If yes,
       JC   m1                            then jump to execution: Cut foil
       A     I      0.0                   Momentary-contact switch: Jog forward
       AN    I      0.1                   Interlock with jog backward
       AN    I      0.3                   Interlock with automatic
       =     DB10.DBX   12.0              Start jog forward
       A     I      0.1                   Momentary-contact switch: Jog backward
       AN    I      0.0                   Interlock with jog forward
       AN    I      0.3                   Interlock with automatic
       =     DB10.DBX   12.1              Start jog backward
       A     I      0.2                   Momentary-contact switch: Cut foil and set
                                          reference point
       FP    DB10.DBX   12.7              Edge evaluation for momentary-contact switch
       A     DB10.DBX   13.0              Scan POS:READY for positioning terminated
       S     DB10.DBX   12.4              Set memory marker for job request: Cut foil
```

```
STL (OB 1) (Continued)                     Explanation

   ----------------------------------
   Automatic mode
   ----------------------------------
       AN    I      0.3                    Automatic mode switch
       AN    DB10.DBX   12.5               Auxiliary memory marker for terminating auto-
       BEC                                 matic mode
       AN    DB10.DBX   12.2               Start positioning operation
       S     DB10.DBX   12.2
       S     DB10.DBX   12.5               Set auxiliary memory marker for terminating
       BEC                                 automatic mode
       A     DB10.DBX   13.0               If positioning terminated, then
       S     DB10.DBX   12.4               set memory marker for cutting the foil
       R     DB10.DBX   12.2
       R     DB10.DBX   12.5               Reset auxiliary memory marker
       BEU

---------------------------------------
Cut foil, accept reference point
---------------------------------------
m1:    NOP   0
       A     I 0.7                         Checkback signal from cutter, cutting termi-
                                           nated
       A     DB10.DBX   12.3               Reference point has been accepted by IF as
                                           new actual value
       R     DB10.DBX   12.3               Reset signal
       R     DB10.DBX   12.4               Reset memory marker for cutting job
       R     Q 4.0                         Reset signal for cutter
       L     S5T#500MS                     Waiting time till drive standstill
       A     DB10.DBX   12.4               (e.g.: 500 ms)
       SD    T      1
       A     DB10.DBX   13.0               Positioning terminated,
       A     DB10.DBX   12.4               Memory marker for cutting job set
       A     T      1                      and time out?
       S     DB10.DBX   12.3               Then accept reference point as actual value
       S     Q 4.0                         Start cutting
```

6.10.2 Positioning Paint Cans

Task

We have a conveyor belt on which paint cans stand in a continuous sequence.

At one processing point, the paint cans are filled with paint. The conveyor belt is stopped at the relevant position until filling is completed.

Marginal Conditions for Positioning

The following marginal conditions must be observed when designing the system:

- For mechanical reasons, the velocity must not exceed a system-specific maximum.
- A maximum acceleration must not be exceeded in order to avoid paint spills.
- The positioning operation is to run time-optimally so that as many paint cans as possible can be filled in the shortest time possible.

The motor is controlled via a frequency converter. The frequency converter is controlled by an analog output in order to guarantee as gentle a startup as possible, thus preventing paint spills.

Switching On the System (Setting Up 1st Paint Can)

After switching on the system, the Positioning integrated function is synchronized as follows:

The conveyor belt is moved forward in jog mode via the user program until the reference point switch (BERO) detects the edge of a paint can. Simultaneously, the system synchronizes to the edge of the paint can and the motor is switched off.

Then the positioning operation is started via the user program.

Wiring

Figure 6-27 shows the technology schematic and the wiring of the example. The power section is a frequency converter with an analog output ± 10 V for direction and velocity.

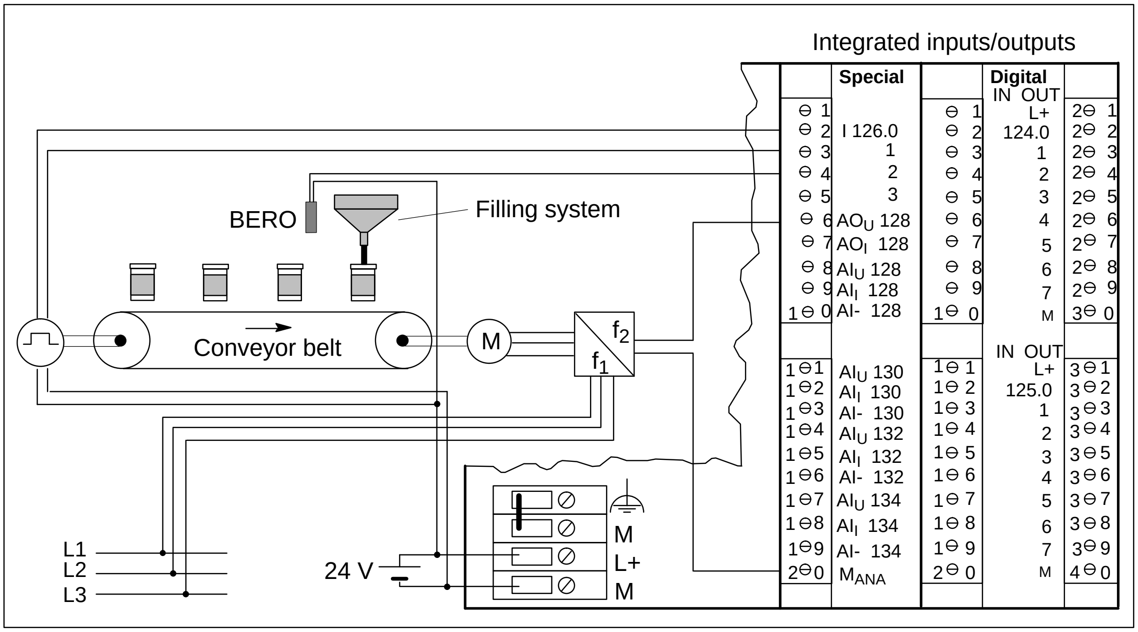

Figure 6-27 Positioning Paint Cans

Function of the Inputs and Outputs

Table 6-25 lists the functions of the inputs and outputs for the example.

Table 6-25 Switching the Inputs and Outputs (Example 2)

Terminal	Input/ Output	Function in the Example
2	I 126.0	Encoder track A
3	I 126.1	Encoder track B
4	I 126.2	Reference point switch
6	AO_U 128	Analog output velocity voltage
20	M_{ANA}	Analog ground
Connection of CPU voltage supply	L+	Supply voltage
Connection of CPU voltage supply	M	Ground

Positioning Operation Sequence (Automatic Mode)

The positioning operation is started via the user program. The conveyor belt travels 300 mm in the forward direction to the destination position (approximate center of paint can).

When the edge of a paint can is detected by the BERO (reference point switch), the system synchronizes at actual value 50 mm. The conveyor belt stops at destination position 300 mm and the paint can is filled. Simultaneously, the system synchronizes to actual value 0 mm.

Figure 6-28 shows a section of the conveyor belt with the values to be specified for positioning in mm.

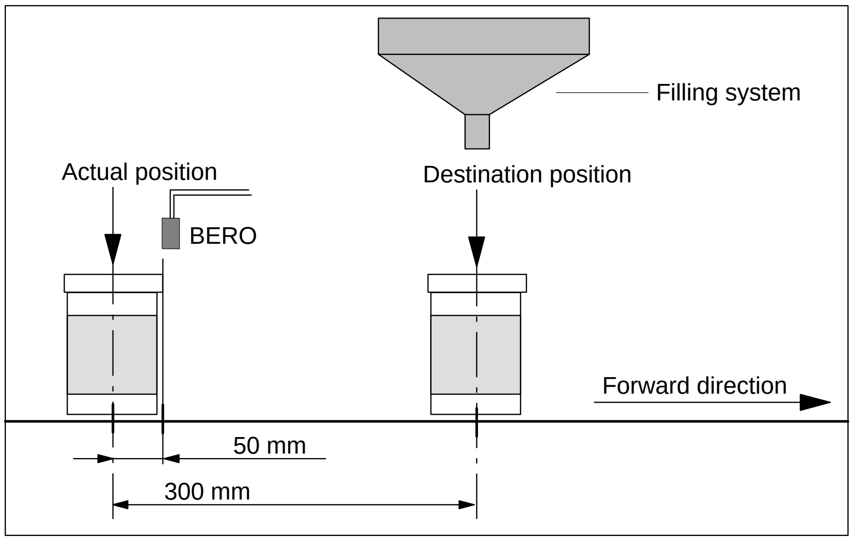

Figure 6-28 Positioning Operation Sequence

New Positioning Operation

When a paint can has been filled, the user program starts a new positioning operation. The conveyor belt travels 300 mm in the forward direction to the destination position and synchronization takes place again to actual value 50 mm at the edge of the paint can.

Assigning mm Distance to Pulses (Distance Increments)

The incremental encoder supplies 100 pulses per revolution. 1 revolution of the incremental encoder corresponds to 5 revolutions of the motor. The incremental encoder therefore supplies 20 pulses per motor revolution. The conveyor belt moves 40 mm per motor revolution.

40 mm : 20 pulses = 2 mm

One pulse is accordingly assigned a distance of 2 mm. 1 pulse corresponds to 1 distance increment.

Assigning Reference Point Switch and Destination Position

In Figure 6-29, you can see assignment of distances/pulses to the reference point switch (BERO) within a positioning operation. Conversion of mm to pulses (distance increments) is as follows:

50 mm : 2 mm = 25 pulses (distance increments)

300 mm : 2 mm = 150 pulses (distance increments)

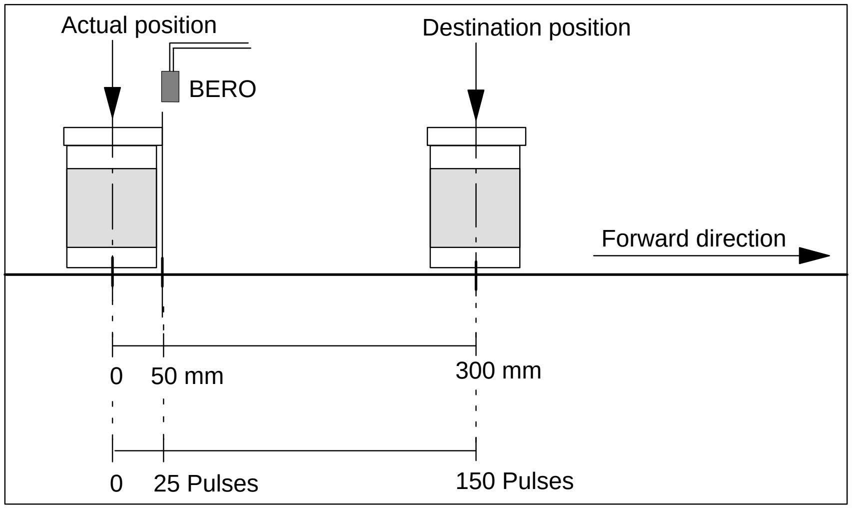

Figure 6-29 Assignment of Distances/Pulses

Distance to be Covered

You specify the destination position of **150** pulses (distance increments) to SFB 39.

Maximum Velocity

5 V is to be output as the maximum analog value at the analog output (v = 5). You specify BREAK = 128 to SFB 39 according to the following equation:

$$v = \frac{10\ V}{256} \times (256 - BREAK) \text{ or } BREAK = 256 \times (1 - \frac{v}{10\ V})$$

Determining the Acceleration/ Stopping Distance

You must parameterize the distance to be traversed from the start of the positioning operation until the maximum velocity is reached.

The maximum velocity is to be reached after 0.1 m. Conversion from mm to pulses is as follows:

100 mm : 2 mm = **50** pulses (distance increments) = Acceleration/stopping distance

Parameterizing with *STEP 7*

You parameterize the CPU with *STEP 7* as follows:

Table 6-26 Parameters for Positioning Paint Cans

Parameter	Input	Explanation
Drive control via	1 analog output (AQ)	The motor is driven via a frequency converter with one analog output ± 10 V for direction and velocity.
Acceleration distance to maximum velocity (= stopping distance to standstill)	50	You define the distance in distance increments in which the analog value is output to the maximum value or reduced to “0”.
Evaluation of the reference point switch for	Forward direction	The reference point switch is evaluated when it is reached in the forward direction.
Number of the instance DB	59	Instance DB for the example (default value)
Automatic updating at the cycle control point	Activated	The instance DB us updated at each cycle control point.

Determining the Switch-Off Difference

To ensure that the destination position is reached as accurately as possible, you must:

1. Specify switch-off difference 0 to SFB 39 via the user program
2. Move the conveyor belt once via the Positioning integrated function
3. Measure the difference between the actual destination position reached and the specified destination position
4. Specify this difference as the switch-off difference to SFB 39

Instance DB of SFB 39

In the example, the data are stored in instance DB 59.

Initialization of SFB 39

Figure 6-30 shows SFB 39 with initialized parameters from DB 2 for setting up the 1st paint can (jog mode).

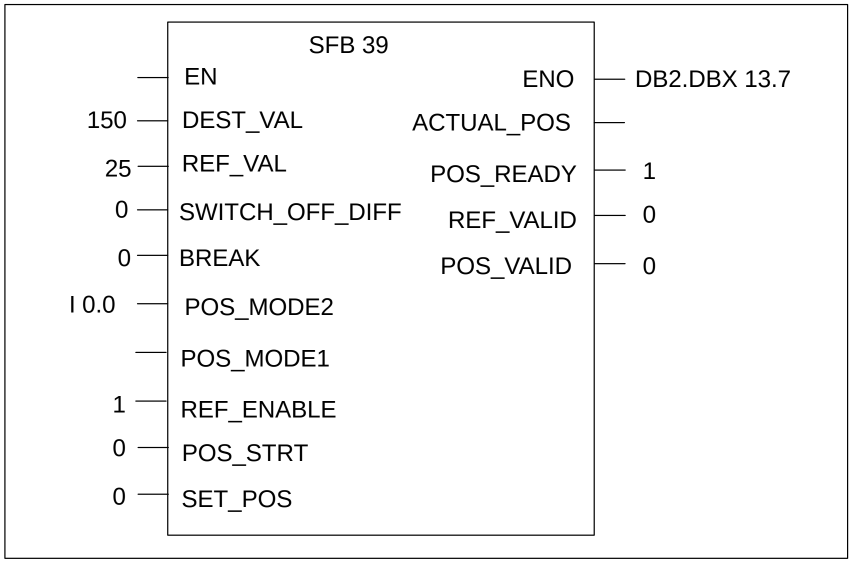

Figure 6-30 Initialization of SFB 39 on Start-Up (2)

User Program

Below is the user program for the example. It has been created with the *STL Editor* in *STEP 7*.

DB 2

The data for SFB 39 are stored in DB 2. The DB has the following structure:

Table 6-27 Example 2: Positioning, DB 2 Structure

Address	Name	Type	Starting Value	Comment
0.0	DEST_VAL	DINT	L#150	Destination position: Center of paint can = 300 m
4.0	Reference point	DINT	L#0	always contains the currently valid reference point (Refp1 or Refp2)
8.0	SWITCH_OFF_DIFF	INT	0	Switch-off difference (calculated at startup)
10.0	Break	BYTE	B#16#80	Maximum velocity (hexadecimal) = 5 V
11.0	---	BYTE	B#16#0	Unused
12.0	Control byte	BYTE	B#16#0	Control bits for positioning
13.0	Checkback byte	BYTE	B#16#0	Checkback status bits from position-ing
14.0	Refp1	DINT	L#25	Reference point for BERO (edge of paint can) = 50 mm
18.0	Refp2	DINT	L#0	Reference point when filling

Statement Section OB 1

You enter the following STL user program in the statement section of OB 1:

```
STL (OB 1)                                  Explanation
Network 1
   ---------------------------------
   Call positioning
   ---------------------------------
       CALL  SFB   39 , DB59
        DEST_VAL       :=DB2.DBD0           Destination pos. (center of paint can = 300 m)
        REF_VAL        :=DB2.DBD4           Reference point for BERO
        SWITCH_OFF_DIFF:=DB2.DBW8           Switch-off difference
        BREAK          :=DB2.DBB10          Maximum velocity
        POS_MODE2      :=DB2.DBX12.0        Jog mode forward
        POS_MODE1      :=
        REF_ENABLE     :=DB2.DBX12.1        Control signal: Evaluate reference point switch
        POS_STRT       :=DB2.DBX12.2        Start positioning operation
        SET_POS        :=DB2.DBX12.3        Control signal: Accept REF_VAL as new actual
        ACTUAL_POS     :=                   value
        POS_READY      :=DB2.DBX13.0        Checkback signal: Pos. op./jog mode terminated
        REF_VALID      :=DB2.DBX13.1        Checkback signal: Reference point switch reached
        POS_VALID      :=DB2.DBX13.2        Checkback signal: Synchronization has taken place
       A     BR                             Scanning the BR bit  (= ENO at SFB 39) for
       =     DB2.DBX   13.7                 error evaluation
       A     DB2.DBX   12.6                 Paint can being filled
       JC    m1
   ---------------------------------
   Setting up the first paint can
   ---------------------------------
       A     I      0.0                     Momentary-contact switch: “Set up”
       AN    I      0.1                     Interlock with automatic mode
       AN    DB2.DBX   12.4                 Auxiliary memory marker for ref. point reached
       =     DB2.DBX   12.0                 Start jog mode forward
       S     DB2.DBX   12.1                 Evaluate reference point switch
       L     DB2.DBD   14                   Load reference point for BERO (edge of
       T     DB2.DBD    4                   paint can) as new reference point
       A     DB2.DBX   13.1                 Reference point reached
       FP    DB2.DBX   12.5                 Edge evaluation
       S     DB2.DBX   12.4                 Set memory marker for reference point reached
       AN    I      0.0
       R     DB2.DBX   12.4                 Reset auxiliary marker if momentary-contact
                                            switch “Set up” released
   ---------------------------------
   Automatic mode
   ---------------------------------

       AN    I      0.1                     If automatic switch not set and automatic
       AN    DB2.DBX   12.7                 auxiliary marker not set,
       BEC                                  then end
       L     DB2.DBD   14                   Load reference point for BERO
       T     DB2.DBD    4                   (edge of paint can) as new reference point
       AN    DB2.DBX   12.2                 Set: Start positioning operation
       S     DB2.DBX   12.2
       S     DB2.DBX   12.1                 Set control signal: REF_ENABLE
       S     DB2.DBX   12.7                 Set auxiliary marker for targeted terminating
       BEC                                  of automatic mode
       A     DB2.DBX   13.0                 If positioning operation terminated,
       S     DB2.DBX   12.6                 then set marker for filling paint can
       R     DB2.DBX   12.2                 Reset: Start positioning operation
       R     DB2.DBX   12.1                 Reset control signal: Evaluate reference
       BEU                                  point switch
```

```
STL (OB 1) (Continued)                     Explanation

----------------------------------------
Filling the container, accept reference
point
---------------------------------------
m1:     NOP   0
        L     DB2.DBD   18                 Load reference point
        T     DB2.DBD    4                 for filling as new reference point
        A     T      1                     If time out and
        A(
        O     I      0.7                   checkback signal: Paint can full
        ON    DB2.DBX   13.1               or if no paint can found
        )
        R     Q      4.0                   then close filling valve
        =     DB2.DBX   12.3               Set reference point
        R     DB2.DBX   12.6               Reset marker for filling paint can
        R     DB2.DBX   12.7               Reset auxiliary marker for automatic
        L     S5T#500MS                    Waiting time till drive standstill
        A     DB2.DBX   12.6
        SD    T      1
        A    T      1                      If time out
        A     DB2.DBX   13.1               and BERO detected paint can,
        S     Q      4.0                   open filling valve
```

6.10.3 Positioning a Worktable

Introduction

The technical implementation of the example in Section 6.1.2 is shown below.

Task

Let's take again the example of the worktable which is used to position workpieces.

One or more machining operations are performed at a machining point. For this purpose, the worktable is stopped at the relevant position until machining of the workpiece has been completed. The worktable is moved via an axis.

Switching the System On

After switching the system on, the Positioning integrated function is synchronized as follows:

Regardless of the actual position, the worktable is moved backward in jog mode via the user program until it reaches the left limit switch. The motor is switched off.

Following this, the user program controls the worktable in jog mode forward until the right limit switch is reached. On the way, the reference point switch (BERO) is passed and the Positioning integrated function is synchronized. The motor is switched off.

Following this, the positioning operation is started via the user program.

Positioning Operation Sequence (Automatic Mode)

The positioning operation is started via the user program. The worktable travels forward to each of 3 destination points lying in a line at which the workpiece is to be machined. The motor is switched off following the last machining operation.

New Positioning Operation

After the motor has been switched off, the workpiece can be removed. The operator lays a new workpiece on the table and starts a new positioning operation via the user program (automatic mode).

Wiring

Figure 6-31 shows the technology schematic and the wiring of the example. The power section is a contactor circuit.

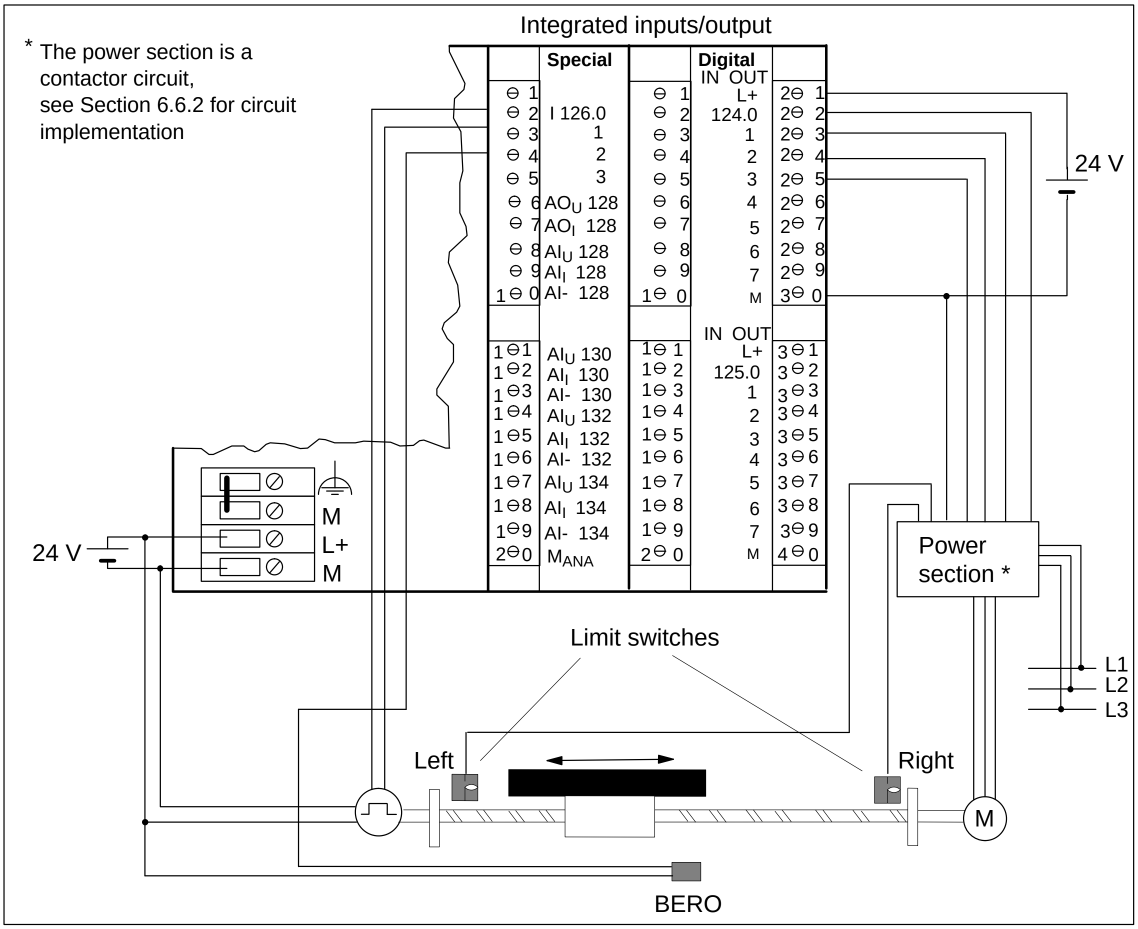

Figure 6-31 Positioning a Worktable

Function of the Inputs and Outputs

Table 6-28 lists the functions of the inputs and outputs for the example.

Table 6-28 Switching the Inputs and Outputs (Example 3)

Terminal	Input/ Output	Function in the Example
2	I 126.0	Encoder track A
3	I 126.1	Encoder track B
4	I 126.2	Reference point switch
21	L+	Supply voltage
22	Q 124.0	Creep speed
23	Q 124.1	Rapid traverse
24	Q 124.2	Backward direction

Table 6-28 Switching the Inputs and Outputs (Example 3)

Terminal	Input/ Output	Function in the Example
25	Q 124.3	Forward direction
30	M	Ground
Connection of CPU voltage supply	L+	Supply voltage
Connection of CPU voltage supply	M	Ground

Assigning mm Distance to Pulses (Distance Increments)

The incremental encoder supplies 250 pulses per revolution. 1 revolution of the incremental encoder corresponds to 10 revolutions of the motor. The incremental encoder therefore supplies 25 pulses per motor revolution. The worktable moves 3 mm per motor revolution.

3 mm : 25 pulses = 0.12 mm

One pulse is accordingly assigned a distance of 0.12 mm. 1 pulse corresponds to 1 distance increment.

In the example, the reference point switch is to be evaluated at each positioning operation. For this reason, it is located at the center of the distnace to be traversed.

In Figure 6-32, you can see the assignment of distances/pulses to the limit switches and the reference point switch (BERO). Conversion of mm to pulses (distance increments) is as follows:

500 mm : 0.12 mm = 4167 pulses (distance increments)

1000 mm : 0.12 mm = 8333 pulses (distance increments)

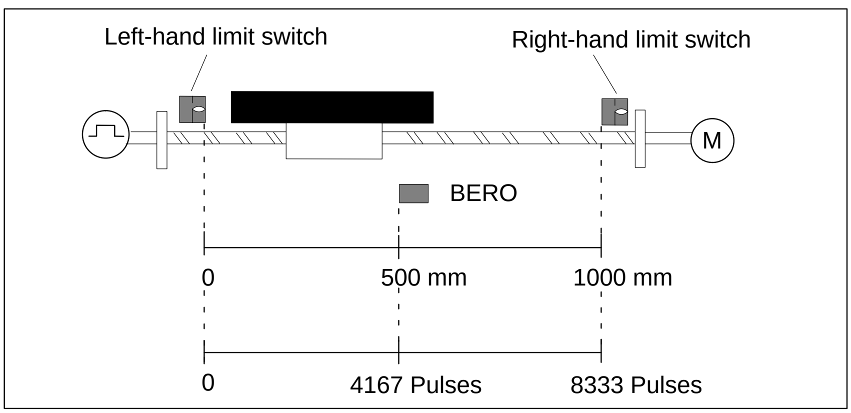

Figure 6-32 Assignment of Distances/Pulses to the Switches

Distance to be Covered

In the example, the worktable approaches 3 different destination positions one after the other:

Destination Position ...	Conversion for Specifying to SFB 39
1: 750 mm	750 mm : 0.12 mm per pulse = **6250** pulses (distance increments)
2: 400 mm	400 mm : 0.12 mm per pulse = **3333** pulses (distance increments)
3: 100 mm	100 mm : 0.12 mm per pulse = **833** pulses (distance increments)

Determining the Acceleration Distance/Stopping Distance

You must parameterize the stopping distance in the example. The stopping distance is the distance traversed at creep speed up to the switch-off point. This distance is set at 60 mm in the example.

60 mm : 0.12 mm per pulse = **500** pulses (distance increments)

Parameterizing with *STEP 7*

You parameterize the CPU with *STEP 7* as follows:

Table 6-29 Parameters for Positioning a Worktable

Parameter	Input	Explanation
Drive control via	4 analog outputs (AQs)	The motor is driven via a contactor circuit in 2 speeds, rapid traverse and creep speed.
Acceleration distance to maximum velocity (= stopping distance)	500	You define the distance in distance increments in which the system accelerates to maximum velocity or traverses at creep speed.
Evaluation of the reference point switch in the case of	Forward direction	The reference point switch is evaluated when it is reached in the forward direction.
Number of the instance DB	59	Instance DB for the example (default value)
Automatic updating at the cycle control point	Activated	The instance DB is updated at each cycle control point.

Determining the Switch-Off Difference

To ensure that the destination position is reached as accurately as possible, you must:

1. Specify switch-off difference 0 to SFB 39 via the user program
2. Move the worktable once via the Positioning integrated function
3. Measure the difference between the actual destination position reached and the specified destination position
4. Specify this difference as the switch-off difference to SFB 39

Instance DB of SFB 39

In the example, the data are stored in instance DB 59.

Initialization of SFB 39

Figure 6-33 shows SFB 39 with initialized parameters from DB 60 for setting up the worktable (jog mode backward).

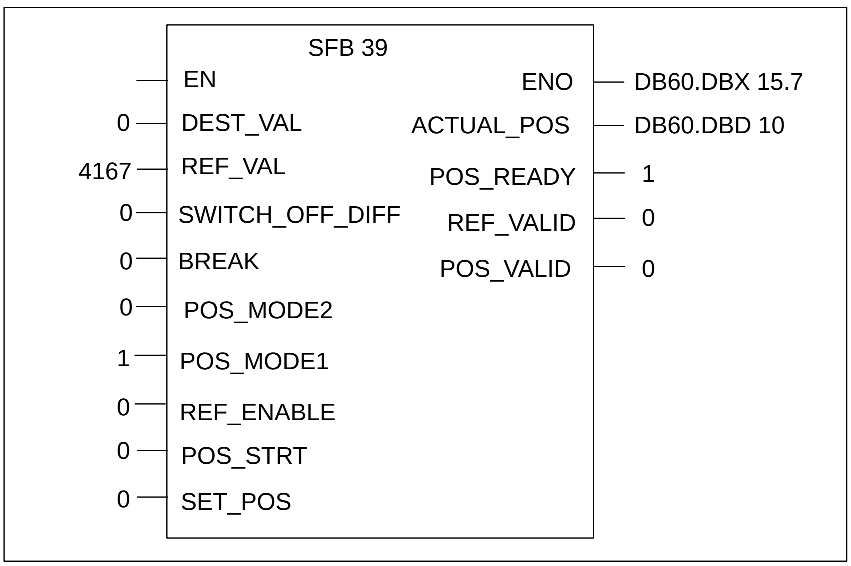

Figure 6-33 Initialization of SFB 39 at Start-Up (3)

User Program

Below is the user program for the example. It has been created with the *STL Editor* in *STEP 7*.

DB 60

The data for SFB 39 are stored in DB 60. The DB has the following structure:

Table 6-30 Example 3: Positioning, Structure of DB 60

Address	Name	Type	Starting value	Comment
0.0		STRUCT		
+0.0	DEST_VAL	DINT	L#0	Always contains the currently valid destination position for drive (SW1, SW2 or SW3)
+4.0	REF_VAL	DINT	L#4167	Reference point for BERO = 500 mm
+8.0	SWITCH_OFF_DIFF	INT	0	Switch-off difference (calculated at startup)
+10.0	ACTUAL_POS	DINT	L#0	Output: Current actual value
+14.0	Control byte	BYTE	B#16#0	Control bits for positioning
+15.0	Checkback byte	BYTE	B#16#0	Checkback status bits from position-ing
+16.0	Istw1	DINT	L#0	Old actual value
+20.0	Sw1	DINT	L#6250	Destination position for 1st machin-ing step (750 mm)
+24.0	Sw2	DINT	L#3333	Destination position for 2nd machin-ing step (400 mm)
+28.0	Sw3	DINT	L#833	Destination position for 3rd machin-ing step (100 mm)
+32.0	SK1	WORD	W#16#0	Auxiliary marker for sequencer
+34.0	SK2	WORD	W#16#0	Counter for jump-to list
=36.0		END_STRUCT		

Statement Section OB 1

You enter the following user program in the statement section of OB 1:

```
STL (OB 1)                                  Explanation
Network 1
------------------------------------
Call positioning
------------------------------------
        CALL  SFB   39 , DB59
         DEST_VAL       :=DB60.DBD0         Destination position for drive
         REF_VAL        :=DB60.DBD4         Reference point for BERO
         SWITCH_OFF_DIFF:=DB60.DBW8         Switch-off difference
         BREAK          :=                  Unassigned means default value applies (0)
         POS_MODE2      :=DB60.DBX14.0      Jog mode forward
         POS_MODE1      :=DB60.DBX14.1      Jog mode backward
         REF_ENABLE     :=DB60.DBX14.2      Control signal: Evaluate reference signal
         POS_STRT       :=DB60.DBX14.3      Start positioning operation
         SET_POS        :=
         ACTUAL_POS     :=DB60.DBD10        Output: Current actual value
         POS_READY      :=DB60.DBX15.0      Checkback signal: Pos. op./jog mode terminated
         REF_VALID      :=DB60.DBX15.1      Checkback signal: Reference point switch reached
         POS_VALID      :=DB60.DBX15.2      Checkback signal: Synchronization has taken place
        A     BR                            Scanning the BR bits (= ENO at SFB 39) for
        =     DB60.DBX   15.7               error evaluation

------------------------------------
Checking that drive is at standstill
------------------------------------
        L     S5T#200MS                     Scan for drive at standstill
        AN    T      1                      If no change in position within 200 ms,
        SD    T      1                      then drive at standstill
        JC    m1
        L     DB60.DBD   16                 Save old actual value and
        L     DB60.DBD   10                 current actual value
        T     DB60.DBD   16                 for next comparison
        ==D
        =     DB60.DBX   14.4               Memory bit for drive at standstill
m1:     NOP   0
        A     DB60.DBX   14.5               Memory bit for processing set
        JC   m13

------------------------------------
Switching the system on
------------------------------------
        A     I      0.0                    Momentary-contact switch “Setup”
        FP    DB60.DBX   32.1               Edge evaluation for momentary-contact switch
        AN    I      0.1                    Interlock  with automatic mode
        AN    DB60.DBX   32.2
        S     DB60.DBX   32.0               Auxiliary marker for “Setup” sequencer
        AN    DB60.DBX   32.0               Jump if not “Setup”
        JC   m8
        L     DB60.DBW   34                 Counter for jump-to list
        JL   m2                             Call jump-to list
        JU    m3                            Traverse to left limit switch
        JU    m4                            Switch off axis
        JU    m5                            Start forward to right limit switch
        JU    m6                            Switch off axis
        JU    m7                            Terminate setup
m2:     L     0
        T     DB60.DBW   34
        BEU
```

```
STL (OB 1) (Continued)                 Explanation

m3:     NOP    0
        AN     DB60.DBX    14.1
        S      DB60.DBX    14.1        Jog mode backward
        A      DB60.DBX    14.4        Axis still at standstill
        BEC
        L      1                       Next step
        T      DB60.DBW    34
        BEU
m4:     NOP    0
        AN     DB60.DBX    15.0        If positioning not terminated
        A      DB60.DBX    14.4        and drive at standstill,
        S      DB60.DBX    14.1        then switch axis to Stop
        S      DB60.DBX    14.0
        ON     DB60.DBX    14.1        Wait for axis stop
        ON     DB60.DBX    14.0
        BEC
        L      2                       Next step
        T      DB60.DBW    34
        BEU
m5:     NOP    0
        A      DB60.DBX    14.0        If Stop signal active,
        A      DB60.DBX    14.1
        R      DB60.DBX    14.1        then reset Stop signal
        R      DB60.DBX    14.0
        BEC
        SET
        S      DB60.DBX    14.0        Jog mode forward
        S      DB60.DBX    14.2        Set control signal: REF_ENABLE
        A      DB60.DBX    14.4        Axis still at standstill
        BEC
        L      3                       Next step
        T      DB60.DBW    34
        BEU
m6:     NOP    0
        AN     DB60.DBX    15.0        Positioning not terminated
        A      DB60.DBX    14.4        Drive at standstill
        S      DB60.DBX    14.1        Switch axis to stop
        S      DB60.DBX    14.0
        ON     DB60.DBX    14.0        Wait for axis stop
        ON     DB60.DBX    14.1
        BEC
        L      4                       Next step
        T      DB60.DBW    34
        BEU
m7:     NOP    0                       Terminate setup
        SET
        R      DB60.DBX    14.1        Reset Stop signal
        R      DB60.DBX    14.0        (terminate setup)
        R      DB60.DBX    32.0
        L      0                       Reset counter for jump-to list
        T      DB60.DBW    34
        BEU
m8:     NOP    0
```

```
STL (OB 1) (Continued)                     Explanation

-------------------------------------
Automatic mode
-------------------------------------
        A     I      0.1                   Momentary-contact switch for Automatic
        FP    DB60.DBX   32.3              Edge evaluation for momentary-contact switch
        AN    I      0.0                   Interlock with "Setup"
        AN    DB60.DBX   32.0
        S     DB60.DBX   32.2              Set memory bit for "Automatic" sequencer
        AN    DB60.DBX   32.2              End if not "Automatic"
        BEC
        L     DB60.DBW   34                Counter for jump-to list
        JL    m9                           Call jump-to list
        JU    m10                          Load 1st destination position
        JU    m11                          Load 2nd destination position
        JU    m12                          Load 3rd destination position
m9:     L     0
        T     DB60.DBW   34
        BEU
m10:    NOP   0
        L     DB60.DBD   20                Load destination position for 1st machining step
        T     DB60.DBD    0                Save it as destination position for drive
        AN    DB60.DBX   14.3              Start positioning operation
        S     DB60.DBX   14.3
        BEC
        ON    DB60.DBX   15.0              If positioning operation not yet terminated
        ON    DB60.DBX   14.4              or drive running
        BEC
        L     1                            Next step
        T     DB60.DBW   34
        SET
        R     DB60.DBX   14.3              Reset control signal for start positioning
                                           operation
        S     DB60.DBX   14.5              Start machining
        BEU
m11:    NOP   0
        L     DB60.DBD   24                Load destination position for 2nd machining step
        T     DB60.DBD    0                Save it as destination position for drive
        AN    DB60.DBX   14.3              Start positioning operation
        S     DB60.DBX   14.3
        BEC
        ON    DB60.DBX   15.0              If positioning operation not yet
        ON    DB60.DBX   14.4              terminated or drive running
        BEC
        L     2                            Next step
        T     DB60.DBW   34
        SET
        R     DB60.DBX   14.3              Reset control signal for start positioning
                                           operation
        S     DB60.DBX   14.5              Start machining
        BEU
```

STL (OB 1) (Continued)				Explanation
m12:	NOP	0		
	L	DB60.DBD	28	Load destination position for 3rd machining step
	T	DB60.DBD	0	Save it as destination position for drive
	AN	DB60.DBX	14.3	Start positioning operation
	S	DB60.DBX	14.3	
	BEC			
	ON	DB60.DBX	15.0	If positioning operation not yet terminated
	ON	DB60.DBX	14.4	or drive running
	BEC			
	L	0		Next step
	T	DB60.DBW	34	
	SET			
	R	DB60.DBX	14.3	Reset control signal for start positioning operation
	S	DB60.DBX	14.5	Start machining
	R	DB60.DBX	32.2	Terminate automatic mode
	BEU			

Machining				
------------------------------------				
m13:	NOP	0		Simulation of machining via waiting time
	A	T 2		
	R	DB60.DBX	14.5	Terminate machining
	L	S5T#2S		
	A	DB60.DBX	14.5	
	SD	T 2		

Technical Specifications of the Frequency Meter Integrated Function

A

Technical Specifications

In Table A-1 you will find the technical specifications for the Frequency Meter integrated function.

Table A-1 Technical Specifications for Frequency Meter Integrated Function

No. of frequency meters	1
Measuring range	32 bits: from 0 to 10000000 mHz
Sample times	0.1 s/1 s/10 s
Measured signal	• Frequency limit: 10 kHz • Pulse time: ≥ 50 µs • Pulse interval: ≥ 50 µs • Signal state HIGH: ≥ 15 V • Signal state LOW: ≤ 5 V
Digital inputs of the integrated inputs/outputs	Measurement: • CPU 312 IFM I 124.6 (terminal 8) • CPU 314 IFM I 126.0 (terminal 2)
DC supply voltage	• CPU 312 IFM 24 V DC (terminal 18) • CPU 314 IFM 24 V DC (connected at CPU voltage supply)
Ground	• CPU 312 IFM reference potential of supply voltage (terminals 19/20; internally jumpered) • CPU 314 IFM reference potential of supply voltage (connected at CPU voltage supply)
System function block	SFB 30

Figure A-1 shows the properties of the measured signal:

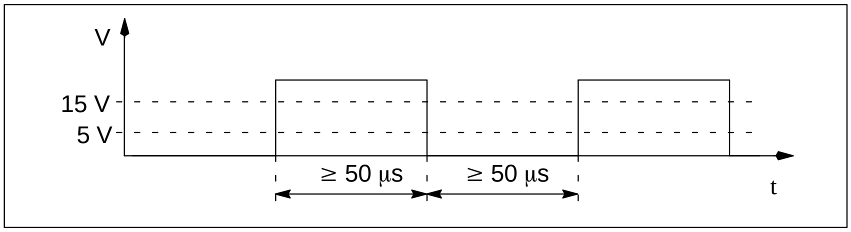

Figure A-1 Properties of the Measured Signal

Technical Specifications of the Counter Integrated Function

B

Technical Specifications

In Table B-1 you will find the technical specifications for the Counter integrated function.

Table B-1 Technical Specifications for Counter Integrated Function

No. of counters	1
Counting range	32 bits: from -2147483648 to 2147483647
Counting direction	Up and down
Counting pulse	• Frequency limit: 10 kHz • Pulse time: ≥ 50 µs • Pulse interval: ≥ 50 µs • Signal state HIGH: ≥ 15 V • Signal state LOW: ≤ 5 V
Digital inputs of the integrated inputs/outputs	CPU 312 IFM: • Up: I 124.6 (terminal 8) • Down: I 124.7 (terminal 9) • Direction: I 125.0 (terminal 10) • Hardware start/stop: I 125.1 (terminal 11) CPU 314 IFM: • Up: I 126.0 (terminal 2) • Down: I 126.1 (terminal 3) • Direction: I 126.2 (terminal 4) • Hardware start/stop: I 126.3 (terminal 5)
DC supply voltage	• CPU 312 IFM 24 V DC (terminal 18) • CPU 314 IFM 24 V DC (connected at CPU voltage supply)
Ground	• CPU 312 IFM reference potential of supply voltage (terminals 19/20; internally jumpered) • CPU 314 IFM reference potential of supply voltage (connected at CPU voltage supply)

Table B-1 Technical Specifications for Counter Integrated Function

Digital outputs of the integrated inputs/outputs	• Digital output A: Q 124.0 – CPU 312 IFM (terminal 12) – CPU 314 IFM (terminal 22) • Digital output B: Q 124.1 – CPU 312 IFM (terminal 13) – CPU 314 IFM (terminal 23)
System function block	SFB 29

Figure B-1 shows the properties of the counting pulses:

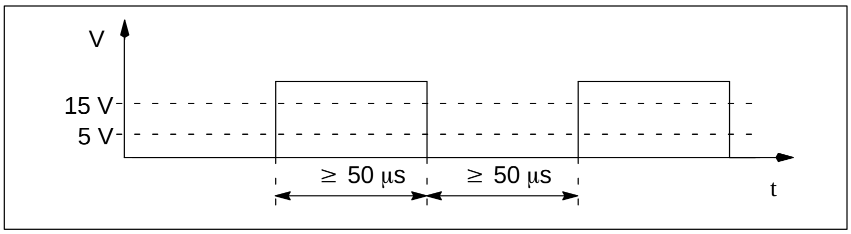

Figure B-1 Properties of the Counting Pulse

Technical Specifications of the Counter A/B Integrated Function (CPU 314 IFM)

C

Technical Specifications

Table C-1 lists the technical specifications of the Counter A/B integrated function.

Table C-1 Technical Specifications of the Counter A/B Integrated Function

Number of counters	2
Count range	32 bits: from –2147483648 to 2147483647
Count direction	Up and down
Counter pulse	• Limit frequency: **10 kHz** • Pulse duration: ≥ 50 µs • Pulse-pause: ≥ 50 µs • Signal state HIGH: ≥ 15 V • Signal state LOW: ≤ 5 V
Digital inputs of the integrated inputs/outputs	• Counter A: Up (up/down): I 126.0 (Special terminal 2) • Counter A: Down (direction): I 126.1 (Special terminal 3) • Counter B: Up (up/down): I 126.2 (Special terminal 4) • Counter B: Down (direction): I 126.3 (Special terminal 5)
DC supply voltage	24 V DC (connected to CPU voltage supply)
Ground	Reference potential of supply voltage (connected to CPU voltage supply)
Digital outputs of the integrated inputs/outputs	• Counter A: Q 124.0 (Digital 22 terminal) • Counter B: Q 124.1 (Digital 23 terminal)
System function block	SFB 38

Properties of the Counter Pulses

Figure C-1 shows the properties of the counter pulses.

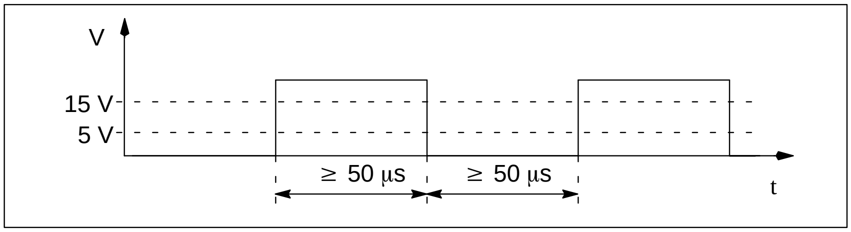

Figure C-1 Properties of the Counter Pulses

Technical Specifications of the Positioning Integrated Function (CPU 314 IFM) D

Technical Specifications

Table D-1 lists the technical specifications of the Positioning integrated function.

Table D-1 Technical Specifications of the Positioning Integrated Function

Digital inputs of the integrated inputs/outputs	• Track A: I 126.0 (Special 2 terminal) • Track B: I 126.1 (Special 3 terminal) • Reference point switch: I 126.2 (Special 4 terminal)
DC supply voltage	24 V DC (connected to CPU voltage supply)
Ground	Reference potential of supply voltage (connected to CPU voltage supply)
M_{ANA}	Analog ground (Analog 20 terminal)
Digital outputs of the integrated inputs/outputs	• Creep speed: Q 124.0 (Digital 22 terminal) • Rapid traverse: Q 124.1 (Digital 23 terminal) • Backward direction Q 124.2 (Digital 24 terminal) • Forward direction Q 124.3 (Digital 25 terminal)
Analog output of the integrated inputs/outputs	• Speed – Voltage AQ_U 128 (Special 6 terminal) – Current AQ_I 128 (Special 7 terminal)
System function block	SFB 39
Encoder inputs, track A and track B	
Position detection	• Incremental
Signal voltage/current	• Asymmetrical inputs: 24 V/typ. 4 mA
Input frequency and cable length for asymmetrical encoders with 24 V supply	• Max. 10 kHz at 100 m shielded cable length

Table D-1 Technical Specifications of the Positioning Integrated Function

Input signals	• Incremental: 2 pulse trains shifted by 90° Zero mark signal
Counter pulse	• Limit frequency: 10 kHz • Pulse duration: ≥ 50 µs • Pulse-pause: ≥ 50 µs • Signal state HIGH: ≥ 18 V • Signal state LOW: ≤ 5 V

Pulse Evaluation

The Positioning integrated function of the CPU 314 IFM performs single evaluation of the encoder counter pulses. Single evaluation means, only the rising edge of pulse train A is evaluated.

Figure D-1 shows the pulse evaluation and the properties of the counter pulses.

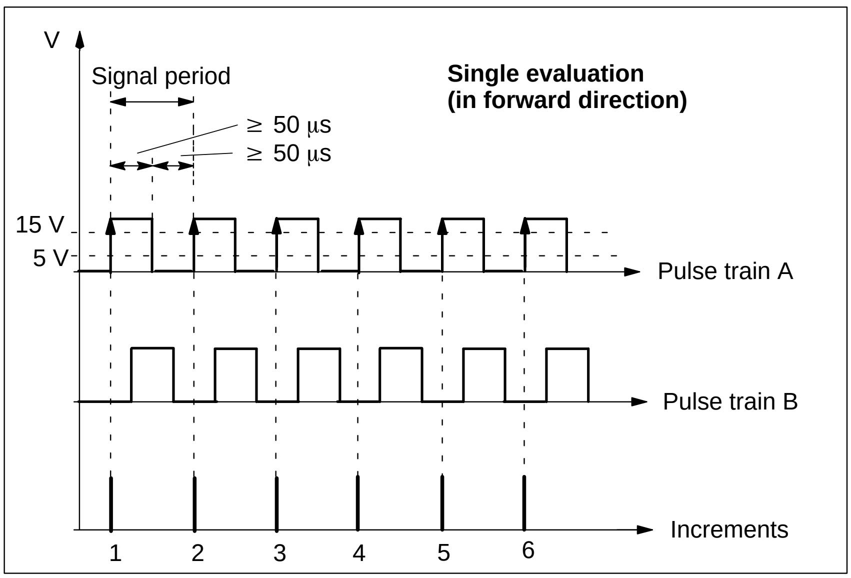

Figure D-1 Pulse Evaluation and Properties of the Counter Pulses

Suitable Incremental Encoders

You can connect the following Siemens incremental encoder to the CPU 314 IFM:

- Incremental encoder U_p=24 V, HTL, Order number: 6FX 2001-4

Terminal Connection Model Encoder 6FX 2001-4

Figure D-2 shows the terminal connection model for the incremental encoder.

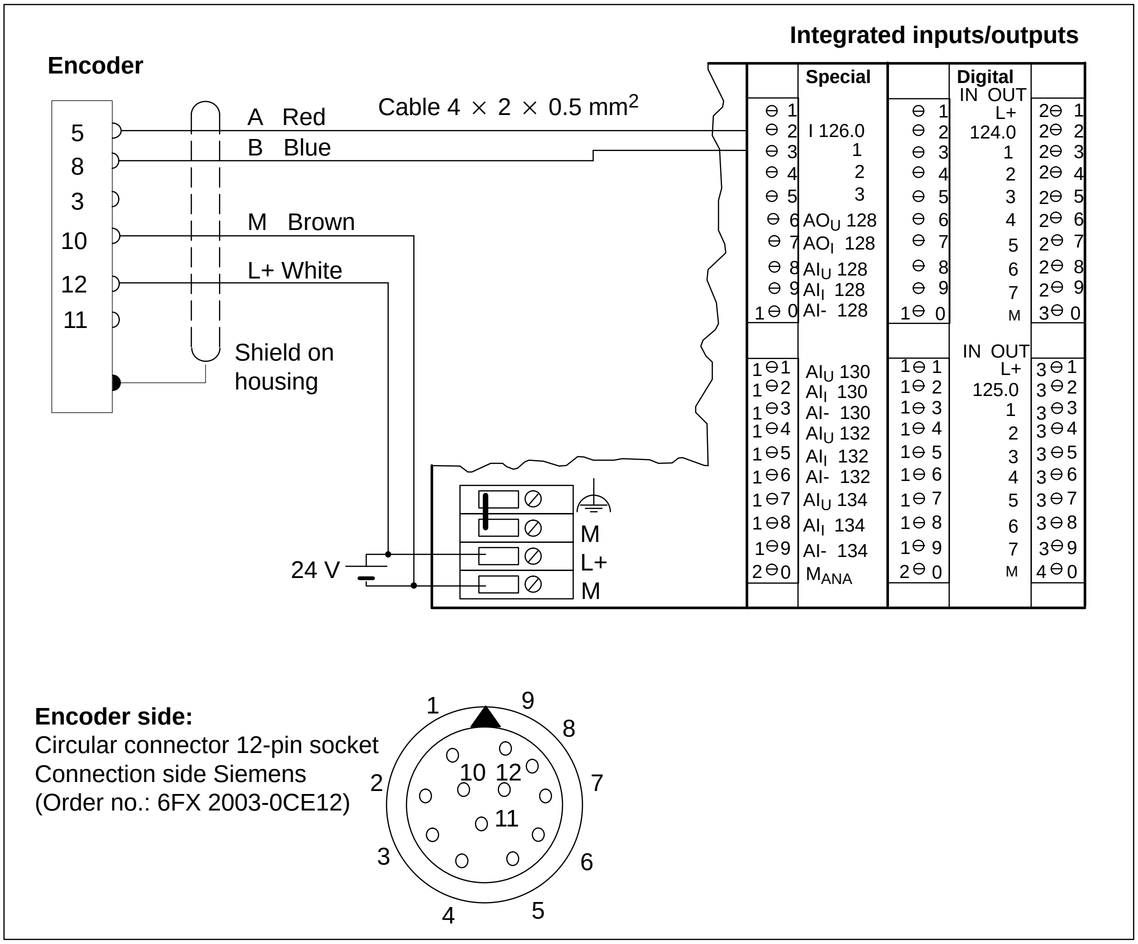

Figure D-2 Terminal Connection Model for Incremental Encoder 6FX 2001-4

Troubleshooting

E

Faults

Table E-1 provides tips on possible faults and how to eliminate them.

Table E-1 Troubleshooting

Fault	**Fault Cause**	**Remedy**
The integrated function no longer operates correctly. There is a communication error (the connection may have been broken).	The frequency limit was exceeded.	Eliminate the cause of the fault
The CPU switches to STOP. Entry in diagnostics buffer: 3501_H (cycle time monitoring)	The cycle load generated by the integrated function is too high. Too many process interrupts have been triggered by the integrated function.	Increase the cycle monitoring time Eliminate the cause of the fault
The CPU switches to STOP. Entry in diagnostics buffer: $35A3_H$ (data block access error) The fault occurs on operating mode changes or at the cycle checkpoint.	The no. of the instance DB in the user program does not match the number configured with *STEP 7*.	Standardize the no. of the instance DB
	The instance DB does not exist, is not long enough or is write-protected.	Create instance DB, change the length or cancel the write protection
SFB output parameter ENO = 0, i.e. the SFB was not executed or was executed with an error.	Input parameter EN = 0 on SFB call.	No error or change user program
	The no. of the instance DB in the user program does not match the number configured with *STEP 7*.	Standardize the no. of the instance DB
	The instance DB does not exist, is not long enough or is write-protected.	Create instance DB, change the length or cancel the write protection
	The integrated function was not activated with *STEP 7*.	Reconfigure the integrated function with *STEP 7*.

SIMATIC S7 Reference Literature

F

Introduction

This Appendix contains references to manuals that you require for starting up and programming the S7-300.

You will also find information on technical books containing information related to the S7-300.

Manuals for Programming and Starting Up

You will need the manuals listed in Table F-1 in order to program and start up an S7-300.

Table F-1 Manuals for Programming and Starting Up of the S7-300

Manual	Contents
Manual *Standard Software for S7 and M7, STEP 7*	• Installing and starting up *STEP 7* on a PC/programming device • Handling *STEP 7* with the following contents: – Processing projects – Configuring and assigning parameters to the hardware – Assigning symbolic names for user program – User program in STL/LAD (overview) – Defining data types, data blocks – Configuring communication between several CPUs – Configuring links – Loading, storing and deleting a user program in the CPU or the programming device – Monitoring and controlling the user program (e.g. variables) – Monitoring and controlling the CPU (e.g. operating state, memory reset, compress memory, protection levels)
Manuals *Statement List (STL) for S7-300 and S7-400, Programming* or *Ladder Logic (LAD) for S7-300 and S7-400, Programming*	• Fundamentals for working with STL/LAD (for example, STL/LAD structure, number formats, syntax) • Description of all operations in STEP 7 (with program examples) • Description of the various types of addressing in STEP 7 (with examples) • Description of the CPU-internal registers
Reference Manual *System Software for S7-300 and S7-400, System and Standard Functions*	• Description of all standard functions integrated in STEP 7 • Description of all system functions integrated in the CPUs • Description of all organization blocks integrated in the CPUs

SIMATIC S7 Reference Literature, Continued

Table F-1 Manuals for Programming and Starting Up of the S7-300, Continued

Manual	Contents
Programming manual *System Software for S7-300 and S7-400, Program Design*	• Procedure for designing user programs • Principle of operation of the CPUs (for example, memory concept, access to inputs and outputs, addressing, blocks, data types, data management) • Description of the STEP 7 data management • Using STEP 7 data types • Using linear and structured programming • Overview for data interchange between programmable modules • Setting system parameters (e.g. time-of-day functions, module parameters and access protection) • Using test and diagnostic functions of the CPUs in the user program (for example, error OBs, status word)
Manual *Standard Software for S7, Converting S5 Programs*	Gives information on converting STEP 5 programs to STEP 7 • Working with the S5/S7 converter • Rules for conversion • Use of converted STEP 5 standard function blocks in STEP 7
Manual *PG 7xx*	• Description of the programming device hardware • Connecting the programming device to various other devices (for example, programmable controllers, further programming devices, printers) • Starting up the programming device

Using the Integrated Functions with the OP3

G

Introduction

The OP3 enables operator interface functionality with standard displays and the use of the integrated functions of the CPU 312 IFM and CPU 314 IFM.

In this Chapter

G.1 Introduction

Standard Configuration/ Standard Displays

A standard configuration for the OP3 is supplied with this manual (on diskette).

This standard configuration contains displays for accessing the integrated functions of the CPU 312 IFM and CPU 314 IFM.

These displays are referred to in this appendix as the standard IF displays.

Features of the Standard Configuration

The standard configuration is ready to use. When it has been installed and transferred to the OP3, you can start using the integrated functions immediately.

With *ProTool/Lite* you can change the standard configuration or the standard displays to suit your application.

The default setting of the integrated functions must not be changed.

G.2 Installing the Standard Configuration on Programming Device/PC and Transferring it to the OP3

Requirements

Before you can install the standard configuration on the Programming device/PC and subsequently transfer it to the OP3, the following requirements must be met:

- *ProTool/Lite* must be installed on the configuring computer (programming device/PC)
- The OP must be connected to a 24 V power supply
- The configuring computer (programming device/PC) must be linked to the OP. The connection is made via the MPI interface (see G.3 for possible arrangements).

Installation Diskette

The diskette supplied contains a standard configuration comprising one display each for accessing the relevant integrated function of the S7-300.

The name of the standard configuration is: IF_BILD.PDB.

Installing the Standard Configuration

Procedure:

1. Insert the diskette in one of the PC/programming device drives
2. Copy the file IF_BILD.PDB into the directory Prolite/Standard
3. Call up *ProTool/Lite* and open the configuration

Transferring the Configuration to the OP

Transfer the configuration to the OP3 as described in the *ProTool/Lite* user manual.

G.3 System Configuration for Installation and Operation

Connecting a Configuring Computer to the OP3

The configuring computer must be linked to the OP3 to transfer the standard configuration to it.

The link can be made in the following ways:

- Direct connection of the configuring computer to the OP.
- The OP3 is connected to a CPU 312 IFM/CPU 314 IFM. The configuration computer is connected to the CPU via a spur line and then disconnected again after the standard configuration has been transferred.
- The OP3 and the configuring computer are both part of a multiple-node MPI network configuration.

Requirements for Operation

The following requirements must be met before the S7-300 integrated functions can be accessed:

- The integrated functions have been parameterized with STEP 7 and are ready for use (default settings).
- The standard configuration with the displays for the integrated functions must be loaded on the OP3.
- The OP3 is connected to the CPU via the MPI (multipoint interface).

Further Information

You will find detailed information on the connection facilities and the structure of an MPI network in the *OP3* manual or in the manual *S7-300 Programmable Controller, Installation and Hardware*.

System Configuration of OP3 and S7 Programming Device/PC

The following arrangements for configuring and operation are intended as examples to illustrate the connection possibilities. You will find more detailed information in the relevant manuals.

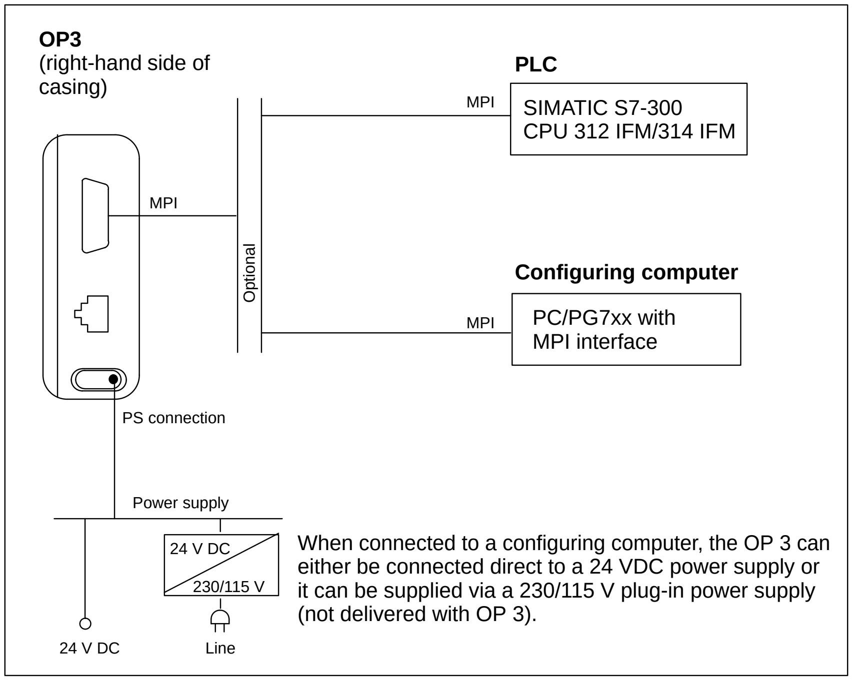

Figure G-1 Point-to-Point Connection (Setup for Configuring the OP3)

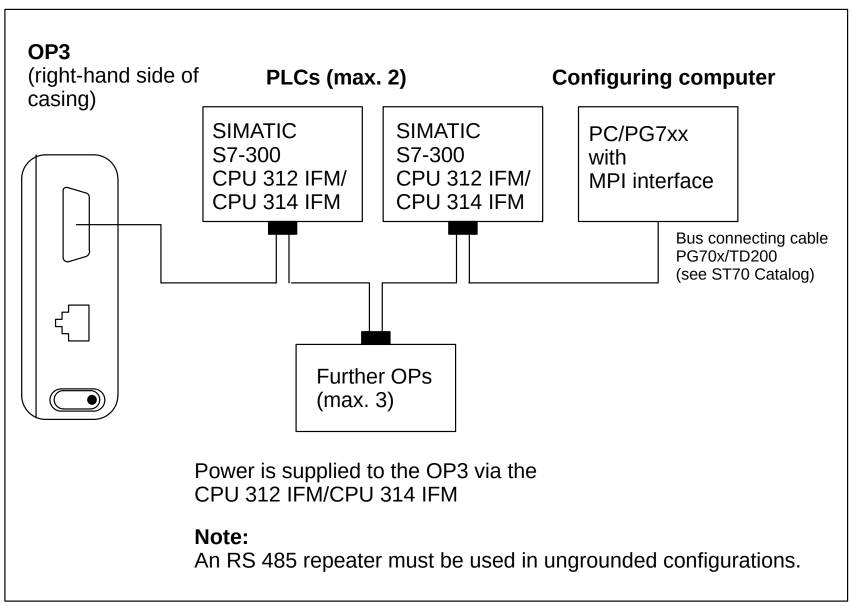

Figure G-2 Multipoint Connection

G.4 Selecting and Using Standard IF Displays

Frame of Reference

The following descriptions of how to select and use the standard IF displays are based on the standard configuration supplied.

General Operations

The descriptions deal only with special operator actions in connection with the standard IF displays.

General operations, such as entering values, cancelling entries, etc., are described in the *OP3* manual.

G.4.1 Selecting the Standard IF Displays

Operating Hierarchy

Figure G-3 shows the position of the standard IF displays in the standard configuration.

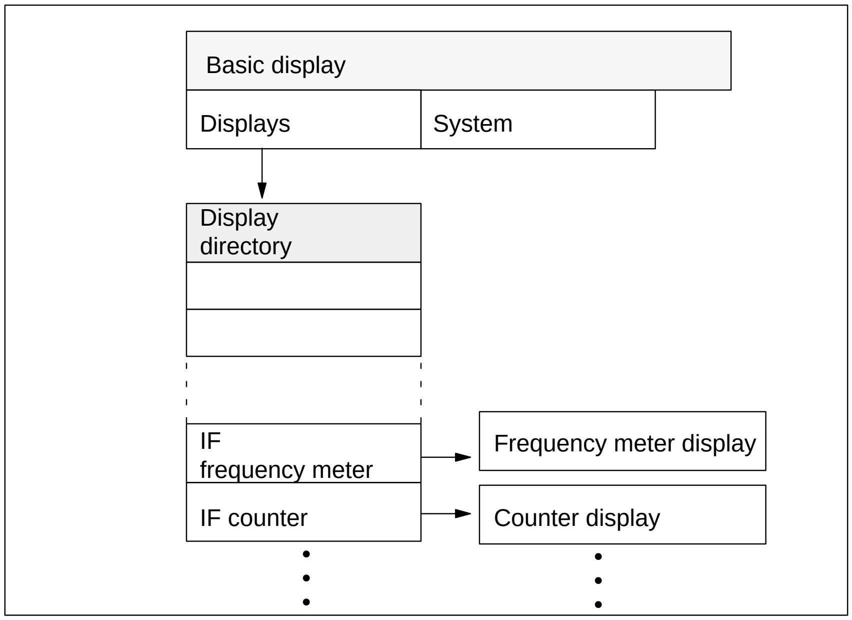

Figure G-3 Operating Hierarchy

Selecting the Standard IF Displays

The integrated functions are accessed via the standard IF displays. To select one of these displays, proceed as follows:

Table G-1 Selecting the Standard IF Displays

Step	Description	Operator Action on OP3
1	Choose “Displays” in the initial display. The list of displays appears.	F2 (SHIFT + 2)
2	Select one of the standard IF displays from the list of displays	↓ , ↑
3	Call up the display	(Enter)

G.4.2 Using the Standard Display for the Frequency Meter IF

Structure

The standard display for the Frequency Meter IF has the following structure:

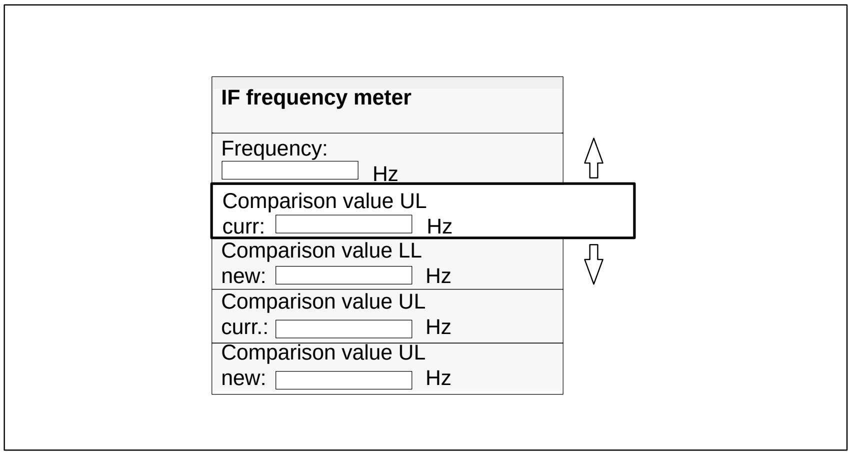

Figure G-4 Structure of the Standard Display for the Frequency Meter IF

Key to Display Items

The following table shows the meanings of the individual display items and the possible operator actions on the OP.

Table G-2 Standard Display for the Frequency Meter IF

Item	Meaning/Function	Operator Action on OP
Frequency	Current frequency display	–
Comparison val. LL current	Display of current comparison value for LL comparator	–
Comparison val. LL new	Display/entry of new comparison value for LL comparator	Entry: 0 ... 10.000
Comparison value UL current	Display of current comparison value for UL comparator	–
Comparison value UL new	Display/entry of new comparison value for UL comparator	Entry: 0 ... 10.000

G.4.3 Using the Standard Display for the Counter IF

Structure

The structure of the standard display for the Counter IF is as follows:

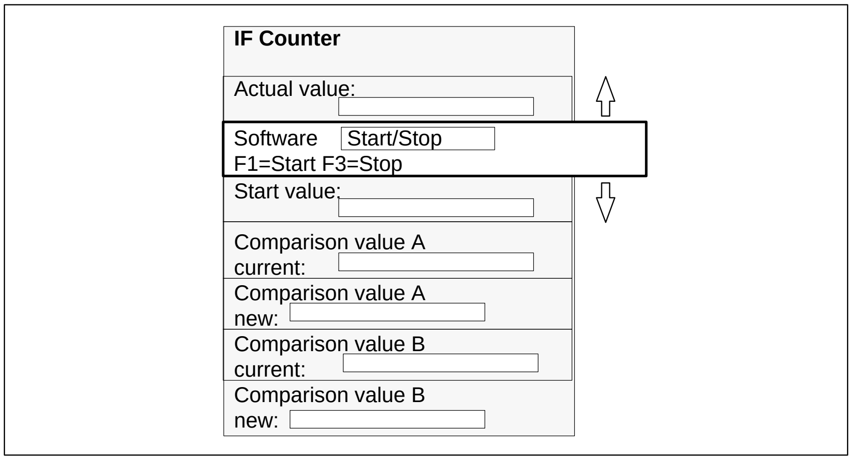

Figure G-5 Structure of the Standard Display for the Counter IF

Key to Display Items

The following table shows the meanings of the individual display items and the possible operator actions on the OP.

Table G-3 Standard Display for the Counter IF

Item	Meaning/Function	Operator Action on OP
Actual value	Current counter status display	–
Software Start/Stop	Starting/stopping counter Display of the current start/stop status	Selection list: Start or Stop*
Start value	Display/entry of the start value from which the counter is to start counting	Entry: -2,147,483,648 to +2,147,483,647
Comparison value A current	Display of current comparison value for comparator A	–
Comparison value A new	Display/entry of a new comparison value for comparator A	Entry: -2,147,483,648 to +2,147,483,647
Comparison value B current	Display of current comparison value for comparator B	–
Comparison value B new	Display/entry of a new comparison value for comparator B	Entry: -2,147,483,648 to +2,147,483,647

* You can also start the counter with the “F1” key and stop it with the “F3” key in each display item.

G.4.4 Using the Standard Display for the Counter A/B IF

Structure

The standard display for the Counter A/B IF has the following structure:

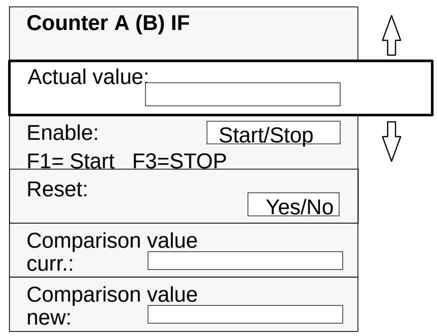

Figure G-6 Structure of the Standard Display for the Counter A/B IF

Key to Display Items

Table G-4 shows the meanings of the individual display items and the possible operator actions on the OP:

Table G-4 Standard Display for the Counter A/B IF

Item	Meaning/Function	Operator Action on OP
Actual value	Display of the current counter value	–
Enable	Starting or stopping the counter Display of the current start/stop status	Selection list: Start or Stop*
Reset	Reset counter to parameterized reset value	Selection list: Yes or No
Comparison value current	Display of current comparison value	–
Comparison value new	Display/entry of a new comparison value	Entry: –2,147,483,648 to +2,147,483,647

* You can also start the counter with the “F1” key and stop it with the “F3” key in each display item.

G.4.5 Using the Standard Display for the Positioning IF

Structure

The standard display for the Positioning IF has the following structure:

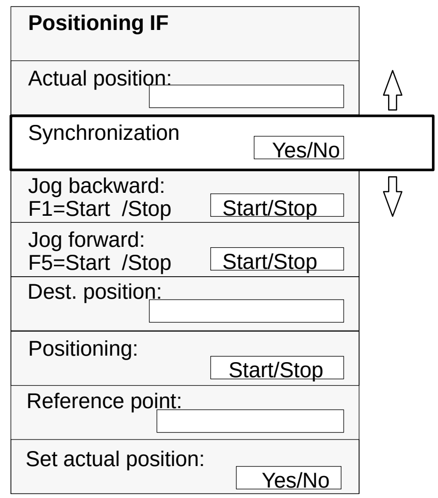

Figure G-7 Structure of the Standard Display for Positioning IF

Key to Display Items

Table G-5 shows the meanings of the individual display items and the possible operator actions on the OP:

Table G-5 Standard Display for the Positioning IF

Item	Meaning/Function	Operator Action on OP
Actual position	Display of current actual position	--
Synchronization	Indication of whether actual position is valid	--
Jog backward	Starting and stopping jog backward	Selection list: Start or Stop*
Jog forward	Starting and stopping jog forward	Selection list: Start or Stop*
Destination position	Entry of destination position	Entry: –2,147,483,648 to +2,147,483,647
Positioning	Starting or terminating of the positioning operation	Selection list: Start or Stop
Reference point	Entry of a new reference point	Entry: –2,147,483,648 to +2,147,483,647

Table G-5 Standard Display for the Positioning IF

Item	Meaning/Function	Operator Action on OP
Set actual position	Accept new reference point as new actual position	Selection list: Yes or no

* In each display item, you can also:
start jog mode backward by pressing and holding the “F1” key
stop jog mode backward by releasing the “F1” key
start jog mode forward by pressing and holding the “F5” key
stop jog mode forward by releasing the “F5” key

G.5 Using the Standard IF Displays in ***ProTool/Lite***

Section Overview

G.5.1 Items and Variables in the Standard IF Displays

Standard Configuration

The standard configuration includes the following displays for the integrated functions:

Table G-6 Names and Functions of the Standard IF Displays

Standard Configuration IF_BILD.PDB	
Display Name	Function
ZIF_FREQ	Frequency Meter
ZIF_COUNTER	Counter
ZIF_HSC_A	Counter A
ZIF_HSC_B	Counter B
ZIF_POS	Positioning

Items and Variables

The following tables show

- the individual items in each display

  and

- the address areas accessed by the variables used

The functions and names of the variables in the standard displays correspond exactly to the input and output parameters of the instance DBs.

For detailed information on the input/output parameters of the instance DBs please refer to chapters 3 and 4 of this manual.

Tabelle G-7 ZIF_FREQ: Items and Variables

ZIF_FREQ					
Text	Variable Name	Address		Type	Remarks
Frequency:	FREQ	DB62	DBD10	Output	Current frequency value
Comparison val. LL current	L_LIMIT	DB62	DBD18	Output	Current lower limit comparison value
Comparison val. LL new	PRES_L_LIMIT	DB62	DBD4	Input/Output	New lower limit comparison value
Comparison value UL current	U_LIMIT	DB62	DBD14	Output	Current upper limit comparison value
Comparison value UL new	PRES_U_LIMIT	DB62	DBD0	Input/Output	New upper limit comparison value

Table G-8 ZIF_COUNTER: Items and Variables

ZIF_COUNTER					
Text	**Variable Name**	**Address**		**Type**	**Remarks**
Actual value	COUNT	DB 63	DBD14	Output	Current counter status
Software Start/Stop[1]	EN_COUNT	DB 63	DBX12.0	Output	Start/Stop counter
Start value	PRES_COUNT	DB 63	DBD0	Input/output	Start value of counter
Comparison value A current	COMP_A	DB 63	DBD18	Output	Current comparison value A
Comparison value A new	PRES_COMP_A	DB 63	DBD4	Input/output	New comparison value A
Comparison value B current	COMP_B	DB 63	DBD22	Output	Current comparison value B
Comparison value B new	PRES_COMP_B	DB 63	DBD8	Input/output	New comparison value B

Table G-9 ZIF_HSC_A or ZIF_HSC_B: Entries and Variables

ZIF_COUNTER					
Text	**Variable Name**	**Address**		**Type**	**Remarks**
Actual value	A_COUNT[1]	DB 60*	DBD6	Output	Current counter status
Enable	A_EN_COUNT[1]	DB 60*	DBX4.0	Input/output	Counter enable
Reset	A_RESET[1]	DB 60*	DBX4.1	Input/output	Reset counter
Comparison value current	A_COMP[1]	DB 60*	DBD10	Output	Current comparison value
Comparison value new	A_PRES_COMP[1]	DB 60*	DBD0	Input/output	New comparison value

1 A_... for counter A; B_... for counter B

* DB 60 for counter A; DB 61 for counter B

Table G-10 ZIF_POS: Entries and Variables

ZIF_POS					
Text	**Variable Name**	**Address**		**Type**	**Remarks**
Actual position	ACTUAL_POS	DB 59	DBD12	Output	Current position
Synchronization	POS_VALID	DB 59	DBX16.2	Output	Actual position is valid
Jog backward	POS_MODE1	DB 59	DBX11.1	Input/output	Jog mode backward
Jog forward	POS_MODE2	DB 59	DBX11.0	Input/output	Jog mode forward
Destination position	DEST_VAL	DB 59	DBD0	Input/output	Destination position
Positioning	POS_STRT	DB 59	DBX11.3	Input/output	Start positioning operation
Reference point	REF_VAL	DB 59	DBD4	Input/output	New reference point
Set actual position	SET_POS	DB 59	DBX11.4	Input/output	Set actual position

G.5.2 Changing the Standard Configuration

Purpose

You can adapt the standard configuration to suit the requirements of your plant or application.

For example, you can modify:

- Operator guidance for calling the standard IF displays
- The treatment of inputs/outputs, e.g. conversion
- The PLC and the data interface to the instance DBs

Examples

The following tables show some of the changes you can make to the configuration.

Table G-11 Modifying Operator Guidance

Operator Guidance		
Configurable:	**Description**	**Menu Item/Dialog Box in *ProTool/Lite***
User-defined operating hierarchy	*ProTool/Lite* enables you to link displays as you like. You can also incorporate IF displays in existing projects	See *ProTool/Lite* documentation
List of contents	You can specify which standard displays you want to include in the list of contents	Display editor: “Display” menu → “Attributes”
Password protection	You can assign the value input variables a password level between 0 and 9	Display editor: Double-click relevant variable → “Input/Output” dialog box

Table G-12 Modifying Displays

Displays		
Configurable:	**Description**	**Menu Item/Dialog Box in *ProTool/Lite***
Display name/title	You can change the symbolic name and the title of a display. The title of the display is also the name of the display entered in the list of contents.	Display editor “Display” menu → “Attributes”
Display items and texts	You can delete, add or modify display items (software inputs/outputs of the IFs) and texts.	Display editor: Editing display items and texts
Linear conversion	You can specify conversion for value input/output. This enables you to enter and monitor values in particular engineering units. The following conversion function is available: **y = a*x+b** a, b: Constants x: Input value y: Value displayed	Display editor: 1. Double-click relevant variable → “Input/Output” dialog box 2. “Edit” button→ “Variable” dialog box 3. “Functions” button → “Functions” dialog box 4. Choose “Linear conversion” 5. “Parameters” button → “Function parameters” dialog box → “Linear conversion” 6. Enter constants “a” and “b”
Range limits for entries	You can specify range limits for value input.	Display editor: 1. Double-click relevant variable → “Input/Output” dialog box 2. “Edit” button → “Variable” dialog box 3. “Limits” button → “Limits” dialog box 4. Specify/change limit values

Table G-13 Modifying the PLC and the Data Interface to the Instance DB

PLC, Data Interface to Instance DB		
Configurable:	**Description**	**Menu Item/Dialog Box in *ProTool/Lite***
Additional PLC	*ProTool/Lite* allows you to configure the OP3 for communication with up to two PLCs.	1. Specifying additional PLC and parameters for MPI: Menu “PLC” → “Controller” “New” button → “Protocol” dialog box 2. Adapting displays and variables: Duplicate all displays and variables requiring access to the second PLC “Variable” dialog box: enter PLC 2 for each duplicated variable
DB Nos. of the instance DBs	The OP3 accesses the instance DBs in the CPU direct. The default numbers for the standard IF displays are: ZIF-FREQ: DB62 ZIF_COUNTER: DB63 ZIF_COUNTER_A: DB 60 ZIF_COUNTER_B: DB 61 ZIF_POS DB 59 **Please note**: If the DB No. of the instance DB in the CPU is changed, all the relevant variables of the individual IF displays must be adapted individually!	Variable Editor: 1. “Variable” -> “Variable” dialog box 2. Enter DB No. again

G.6 Accessing the Instance DB from OP3 and SFB

Function of the Standard IF Displays

The standard IF displays access the input/output variables of the instance DBs of the integrated functions direct. Entries on the OP are written straight to the instance DB.

Access from OP3 and SFB

The user program can also write data to the instance DBs with the SFBs for the integrated functions.

No distinction is made between the OP3 and the user program for either write or read access to the instance DB.

Preventing Access Contention

To prevent simultaneous access to the instance DB from OP3 and PLC, you should ensure that each of the variables in the instance DB is only subject to write access from either the OP3 or the user program when writing your user program.

Glossary

Axis
The axis consists of toothed belt, spindle, toothed rack (pinion), hydraulic cylinder, gears and coupling system.

Changeover Point
At the changeover point, the drive is switched from rapid traverse to creep speed.

Comparator
A comparator compares the actual value of the Counter/Frequency Meter with a defined comparison value and triggers a reaction on certain events. An event occurs when the actual value reaches or falls below a specific counting value or frequency.

Counting Pulses
Counting pulses are positive or negative edges which are counted on the digital inputs of the integrated inputs/outputs and cause the count (current value of the counter) to be incremented/decremented by 1.

Creep Speed
In the case of rapid traverse/creep speed drives, the system changes from rapid traverse to creep speed shortly before the destination position. This increases the accuracy of the positioning.

Destination Position
After a positioning operation is started, the axis approaches the destination position specified by the Positioning integrated function.

Differential Counting
Differential counting determines the difference between incoming and outgoing parts, for example, in a parts store.

Distance per Encoder Revolution
The distance per encoder revolution indicates the distance traveled by the axis in one encoder revolution.

Drive
The drive consists of the power controller and the motor that drives the axis.

Encoders
Encoders are used for accurate capturing of distances, positions and speeds.

Incremental Encoders
Incremental encoders capture distances, positions, velocities, rotational speeds, quantities and more by counting small increments.

Increments per Encoder Revolution
Increments per encoder revolution indicate the number of increments an encoder gives per revolution.

Integrated Inputs/ Outputs
Integrated inputs/outputs are inputs and outputs located on the CPU.

Jog Mode
Jog mode moves the axis “manually” to any position.

Limit Switches
The working range of the axis is defined by 2 limit switches

Open-Loop Positioning
In open-loop positioning, the axis travels to the specified destination position without feedback of the actual value.

Periodic Counting
A periodic counting process is a counting process which is repeated (e.g. counter counts from 1 to 10 and starts again at 1).

Positioning
Positioning means bringing a load to a defined position within a certain time taking account of all influencing forces and torques.

Power Section
The power section is connected to outputs of the integrated inputs/outputs of the CPU 314 IFM. The power section drives the motor and consists of, for example, a contactor circuit.

Quadruple Evaluation
An incremental encoder evaluates all edges (4) of the pulse trains A and B.

Rapid Traverse
The destination position is approached first at rapid traverse.

Rapid Traverse and Creep Speed Drive
A rapid traverse and creep speed drive is a drive that approaches a position on an axis first at rapid traverse and then at creep speed. See also → Rapid Traverse and → Creep Speed

Reference Point
The reference point is the synchronization point between the Positioning integrated function and the actual position of the axis.

Reference Point Approach
A reference point approach synchronizes the Positioning integrated function with the actual position of the axis.

Reference Point Switch

The reference point switch determines the physical position of the reference point.

Sample Time

The sample time is the time interval in which the Integrated Function calculates a curent frequency value at the “Meter” digital input.

Switch-Off Difference

The switch-off difference is the difference in distance between the switch-off point and the destination position.

Switch-Off Point

The drive is switched off at a certain interval (switch-off difference) from the destination. This is the switch-off point. This ensures exact positioning of the axis.

Synchronization

Synchronization informs the Positioning integrated function of the actual position of the axis.

Traverse Range

The traverse range is the range within which the axis can move.

Zero Mark

The zero mark of the encoder supplies a zero mark signal after each revolution of the encoder.

Zero Mark Signal

The zero mark signal is output by an incremental encoder after each revolution.

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