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Length and Speed Measurement using High-Speed Counters (HSC)

SIMATIC S7-1200 from firmware V4.2

https://support.industry.siemens.com/cs/ww/en/view/109754525

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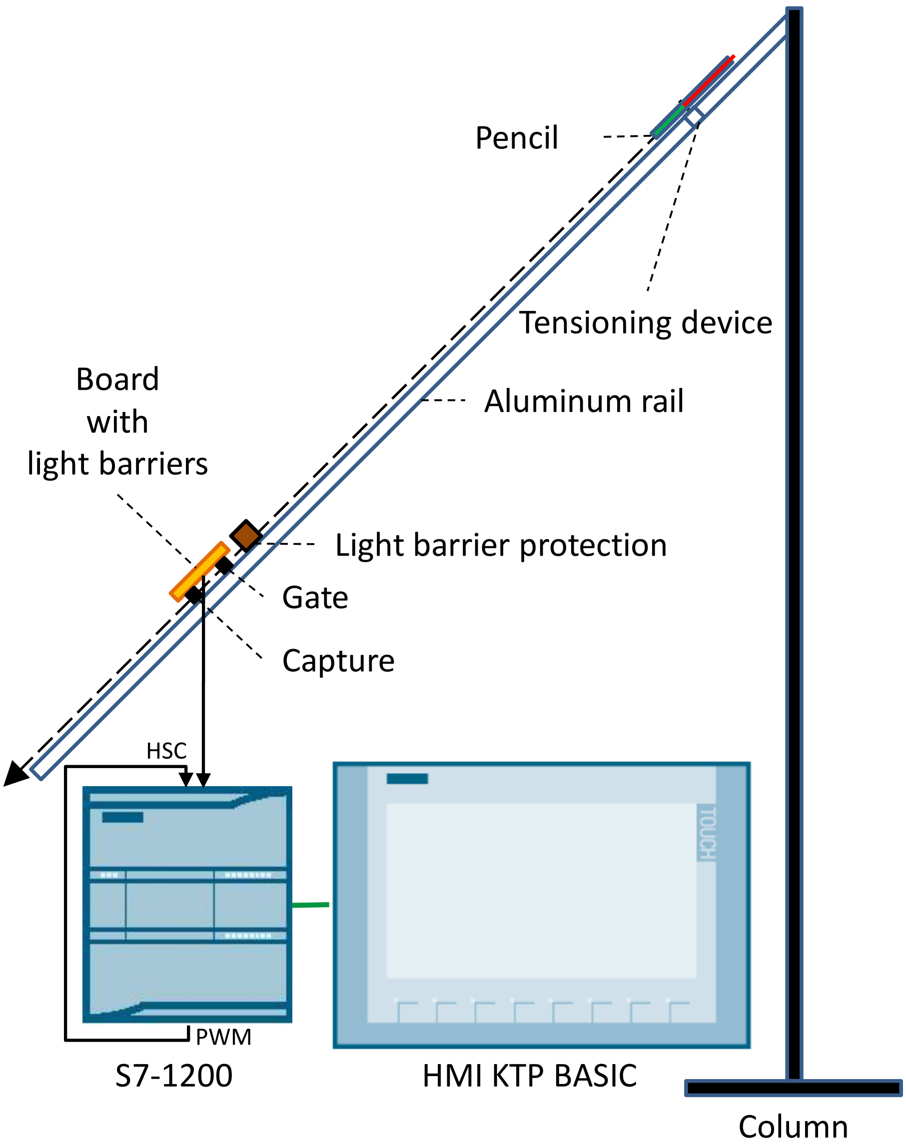
1 Introduction

1.1 Overview

The SIMATIC S7-1200 offers integrated functions such as pulse generators and high-speed counters.
In most cases, high-speed counters are used in conjunction with a rotary encoder to measure motor speed or the distance or length of workpieces on a conveyor belt.

Using the example of the "pencil slingshot", the length and speed measurement is shown strikingly by the high-speed counters, by the simplest means, such as the integrated PWM generator of the S7-1200 and light barriers. You can find a video about this Application Example at:
https://www.youtube.com/watch?v=eB-k6HW58xA

Figure 1-1



1.2 Mode of operation

The device is a sloping aluminum rail on which a pencil is passed through two light barriers (mounted on a board). The light barriers are connected to the digital inputs of the S7-1200. A pulse generator of the S7-1200 outputs constant digital time pulses via pulse width modulation (PWM). The pulse output is fed back to the digital input of the high-speed counter (HSC). When the first light barrier (gate) is darkened, the high-speed counter measures the number of pulses. A second light barrier (capture), at a known distance from the gate light barrier, detects the speed of the pencil. The length of the pencil can be determined from the speed and time of darkening and displayed on an HMI panel.
The pencil is accelerated by the inclined plane and can also be decelerated by a magnet (principle: eddy current brake) or can be re-accelerated with a tensioning device (principle: bow and arrow). A cardboard tunnel is mounted directly in front of the board to guide the pencil and protect the light barriers.

1.3 Components used

The following hardware and software components were used to create this Application Example:

Table 1-1

Component	Number	Article number	Note
CPU 1211C DC/DC/DC	1	6ES7211-1AE40-0XB0	Alternatively, any other CPU of the S7-1200 product family with firmware V4.2.1 (\7\) and transistor outputs (DC) can be used.
Pencils (if possible, coated to minimize friction)	3		Minimum length: Distance between the light barriers
Aluminum profile to guide the pencils	1	Length: 1.5 m	Profile 20x20 mm B-type groove width 6 mm Groove depth 5.5 mm
Cross struts for the tensioning device	2	Length: 0.35 m	The correct size for the aluminum profile
Angle fasteners for the tensioning device	2		The correct size for the aluminum profile
M5 screws to tension the rubber	2		Length 1-1.5 cm
Threaded plate for screws	2		B-type groove 6 [M5]
Strip board with copper lamination (grid 2.54 mm x 2.54 mm)	1		for light barrier mounting
Forked light barrier	2		Manufacturer: Optek Designation: OPB815L e.g. \8\

Component	Number	Article number	Note
Series resistance light barrier	2		1.8 kOhm +/- 1%; 0.6 W
Load resistance for PWM signal improvement	1		560 ohms +/- 5%; 0.5 W
Round magnet for eddy current braking of a pencil	1		Diameter: 4 mm Length: 1-1.5 cm
Rubber sealing rings	2		To accelerate the pencils
Cord	1		Length: approx. 25 cm
Roll of adhesive tape	1		To mount the light barrier board and light barrier protection
Silicone spray for spraying the aluminum rail	1		To minimize friction
SIMATIC HMI KTP700 BASIC	1	6AV2123-2GB03-0AX0	To display the measurement results (can also be simulated in the TIA Portal)
POWER SUPPLY S7-1200 PM1207	1	6EP1332-1SH71	24V power supply of the S7-1200 CPU
STEP 7 Basic V15.1	1	6ES7822-0a.05-..	With Update 1 (\6\) -Also contains WinCC Basic V15.1 for HMI usage

This Application Example consists of the following components:

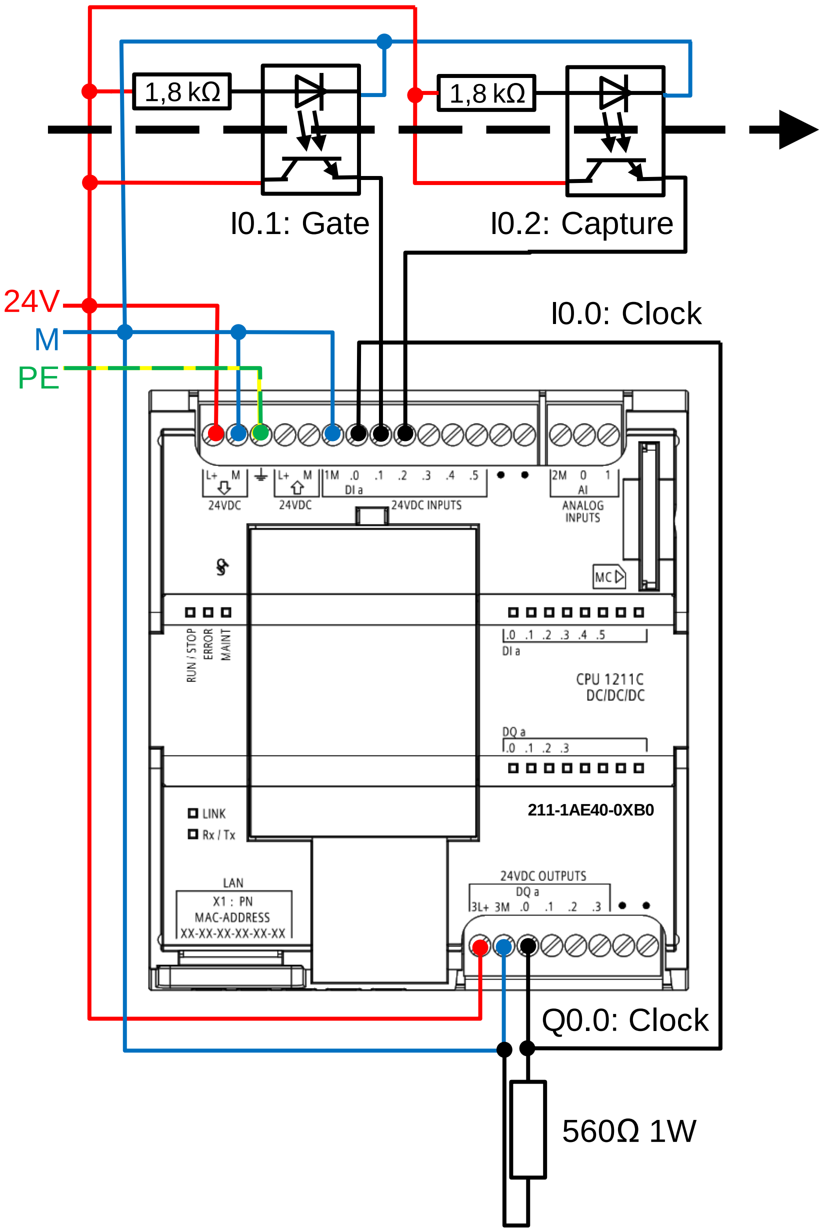
Table 1-2

Component	File name	Note
Documentation	109754525_S71200_HSC_CalcVeloLength_DOC_V11_de.pdf	
STEP 7 project	109754525_S71200_HSC_CalcVeloLength_TiaV15.1_PROJ.zip	

2 Engineering

2.1 Hardware configuration

Figure 2-1



2.1.1 Resistance calculation

Series resistance for the light barrier

The data sheet of the forked light barrier is used to calculate the series resistance for the infrared LED of the light barrier. This is available under the following link:

https://docs-emea.rs-online.com/webdocs/0099/0900766b800999df.pdf

$R_{LED} = U_{L+} / I_F = 24V / 20mA = 1.2\ k\Omega \approx 1.8\ k\Omega$

The test setup was successfully tested with a series resistance of 1.8 kΩ.

Load resistance for the PWM output

Note Depending on the pulse receiver and cable, additional load resistance (at least 10% of the rated current) may improve the quality of the pulse signals and resistance to interference.

$R_{Load} = U_{L+} / (10\% * I_N) = 24V / (10\% * 0.5A) = 480\Omega \approx 560\Omega$

$P_{Loss} = U * I = U * U/R = U^2 / R = 1.03\ W \approx 1W$

Note Since the duty cycle of the PWM signal is 50%, half the dissipation of the load resistance is sufficient (i.e. 0.5W).

2.2 Configuration

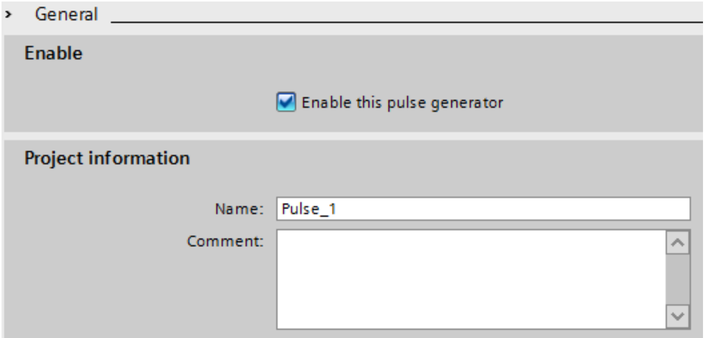
2.2.1 Configuring pulse generators

The maximum frequency of the digital inputs (Ea.0 to Ea.5) of the S7-1200 is 100 kHz. This corresponds to a period duration (cycle time) of 10 µs.

To configure a pulse generator (PWM) with a cycle time of 10 µs and a duty cycle of 50%, proceed as follows:

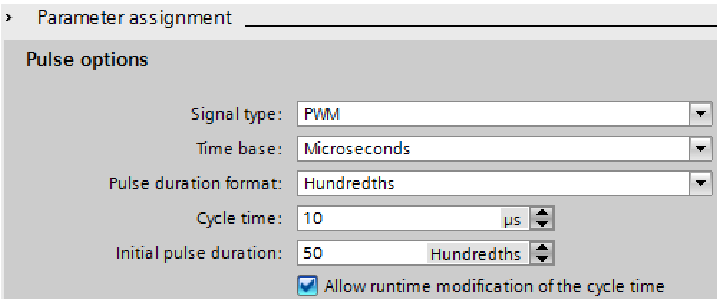
1. Select an S7-1200 CPU in the device or network view.
2. In the Inspector window, under "Properties> General> Pulse generators (PTO/PWM)", click on "PTO1/PWM1".
3. Activate the pulse generator in the parameter group "General" with the corresponding check box. In "Project information", you can enter a name and a comment for the pulse generator.

Figure 2-2: Activate pulse generators



4. Define the pulse options of the pulse generator in the parameter group "Parameter assignment" as follows:
   - "Signal type": "PWM"
   - "Time base": "Microseconds"
   - "Pulse duration format": "Hundredths"
   - "Cycle time": 10 µs
   - "Initial pulse duration": 50 "hundredths"
   - Activate the "Allow runtime modification of the cycle time" option to output the cycle time via the output addresses (Figure 2-5).

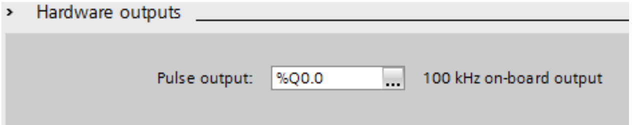
Figure 2-3: Defining pulse generator pulse options



Note	The smaller the cycle time, the more accurately the speed can be determined.

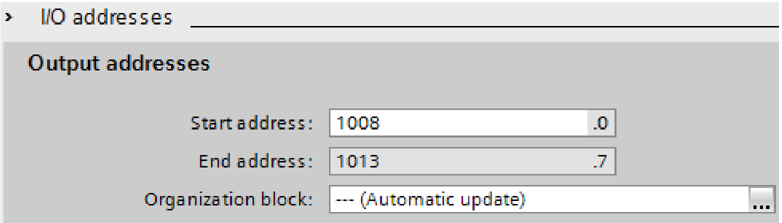
5. In the parameter group "Hardware outputs", for the "Pulse output", enter the hardware output "% Q0.0":

   Figure 2-4: Hardware outputs



6. In the "I/O addresses" area, you set the parameters of the output addresses.

   Figure 2-5: Parameters for output addresses.



   The output addresses allow you to read (or set) the following parameters -> see Figure 2-17:

   QW1008: Pulse duration

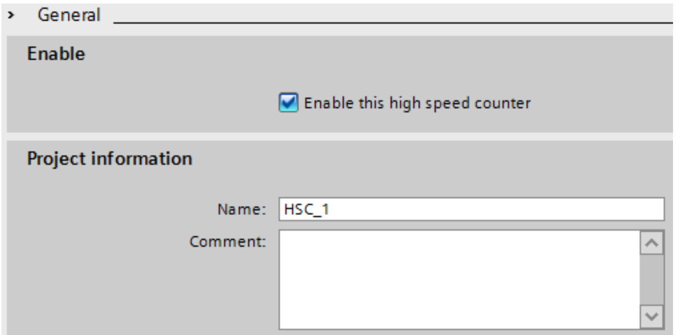
   QD1010: Cycle time

2.2.2 Configuring a high-speed counter

To configure a high-speed counter, follow these steps:

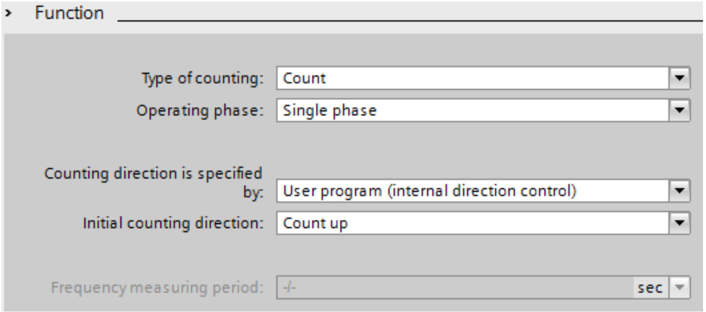
1. Select an S7-1200 CPU in the device or network view.
2. In the Inspector window, under "Properties> General> High speed counters (HSC)", click on the high-speed counter "HSC1".
3. Activate the high-speed counter in the "General" parameter group with the corresponding check box. In "Project information", you can enter a name and a comment for the counter.

   Figure 2-6: Activating the HSC



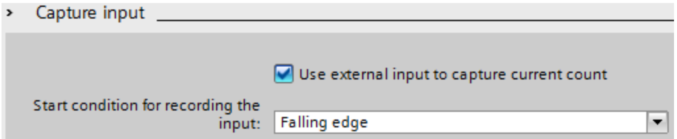
4. Define the function of the counter in the "Function" parameter group as follows:
   - "Type of counting": "Count"
   - "Operating phase": "Single phase"
   - "Counting direction is specified by": "User program (internal direction control)"
   - "Initial counting direction": "Count up"

Figure 2-7: Defining the HSC function



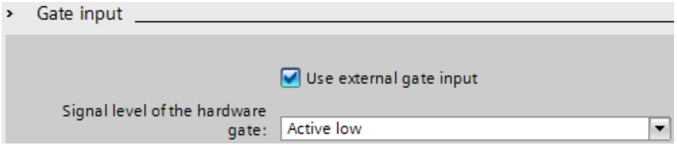
5. Activate the check box "Use external input to capture current count" in the parameter group "Capture input".
   In the "Start condition for recording the input" drop-down list, select the "Falling edge" option.

   Figure 2-8: Activating the capture input



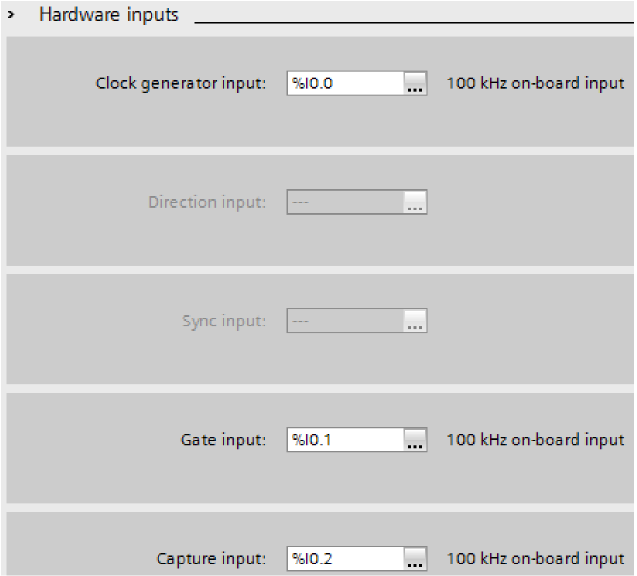
6. Activate the check box "Use external gate input" in the parameter group "Gate input".
   Since we wish to measure the time at which the light barrier signal is interrupted, from the drop-down list "Signal level 11of the hardware gate", select the option "Active low".

   Figure 2-9: Activating the hardware gate



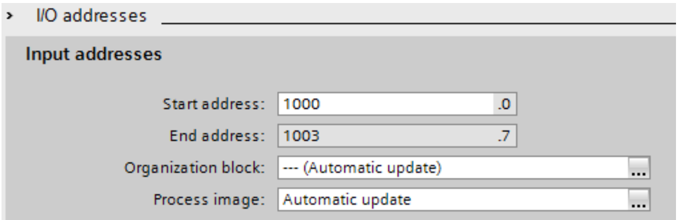
7. Enter the following hardware inputs in the "Hardware inputs" parameter group:
   - "Clock generator input": "%I0.0"
   - "Gate input":"%I0.1"
   - "Capture input":"%I0.2"

Figure 2-10: Hardware inputs



8. In the "I/O addresses" area, you can set the parameters of the input addresses.

   Figure 2-11: Parameters for input addresses.



Note

> The S7-1200 saves the current value of the HSC as DINT in the input address specified under "Start address". You can call up the value, for example, in the watch table via ED1000 (see Chapter 2.4.1) or you can use the count value of the system data type in conjunction with the instruction "CTRL_HSC_EXT" (see Table 2-2).

2.2.3 Configuring a digital input

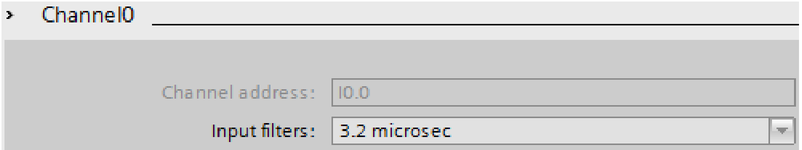
To safely detect the pulses of the inputs to the clock generator and the gate input, you must set the filter time of the digital inputs at a lower value than the duration of the input signal.

F = 100 KHz -> T = 10 µs
Input filter < T/2 = 5 µs

The filter time is set as follows:

1. Select an S7-1200 CPU in the device or network view.
2. In the Inspector window, under "Properties > General > DI 6/DQ 4 > Digital inputs", click on "Channel0".
3. Set the "Input filter" to e.g. "3.2 microsec".

Figure 2-12: Input filter for clock generator



4. Repeat the setting of the "Input filter" of "3.2 microsec" for Channels 1 and 2.

Note

> With smaller filter times, double signals may occur due to the simple light barriers (without Schmitt trigger). Ensure EMC-compliant cable routing. For high-speed counters, it is essential that the input filters are set correctly!

2.3 Interface description

The "CalcVeloLength" FB calculates the speed and length of an object via the high-speed counters of the S7-1200. In this case, a pulse generator is configured for PWM generation and fed back to a digital input. In addition to the clock generator input, the HighSpeedCounter uses the gate input and the capture input.

Figure 2-13 FB "CalcVeloLength"

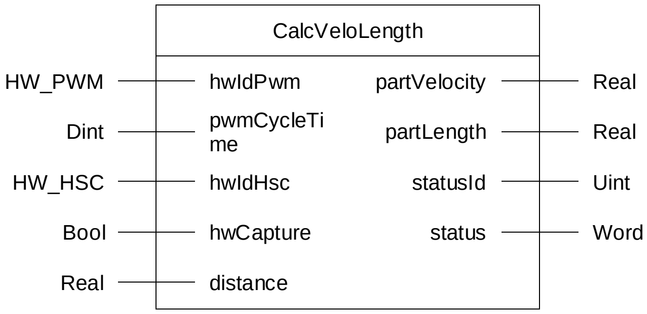


Table 2-1: Parameters of FB "CalcVeloLength"

Name	P-Type	Data type	Comment
hwIdPwm	IN	HW_PWM	Hardware ID of the configured PWM pulse generator (see Chapter 2.3.1)
pwmCycleTime	IN	Dint	Cycle time of the PWM signal in µs (as long as you do not change the time basis in Figure 2-3, you can transfer QD1010 from Figure 2-5 here)
hwIdHsc	IN	HW_HSC	Hardware ID of the configured high-speed counter (see Chapter 2.3.1)
hwCapture	IN	Bool	Hardware input of the capture signal (see Figure 2-10)
distance	IN	Real	Distance between the light barriers [mm]
partVelocity	OUT	Real	Calculated speed of the object
partLength	OUT	Real	Calculated length of the object
statusID	OUT	Uint	Status flag: 0=No error 1 = Error calling instruction "CTRL_PWM" 2 = Error calling instruction "CTRL_HSC_EXT"

Name	P-Type	Data type	Comment
status	OUT	Word	Status of the faulty instruction (see "statusId")

2.3.1 Retrieve hardware ID

The pulse generator and high-speed counter hardware identifiers can be found by displaying all PLC variables. In the "System constants" tab, you will find the name of the configured pulse generator (see Figure 2-2) or high-speed counter (see Figure 2-6) with the prefix "Local~". You can transfer the absolute value or the symbolic name to the respective interface parameter in Table 2-1.

Figure 2-14

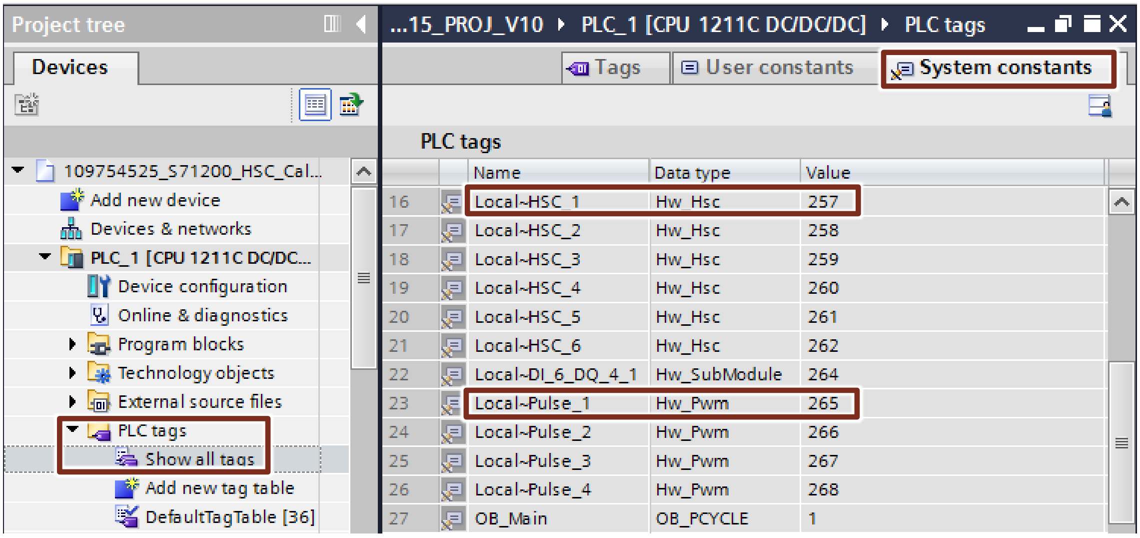
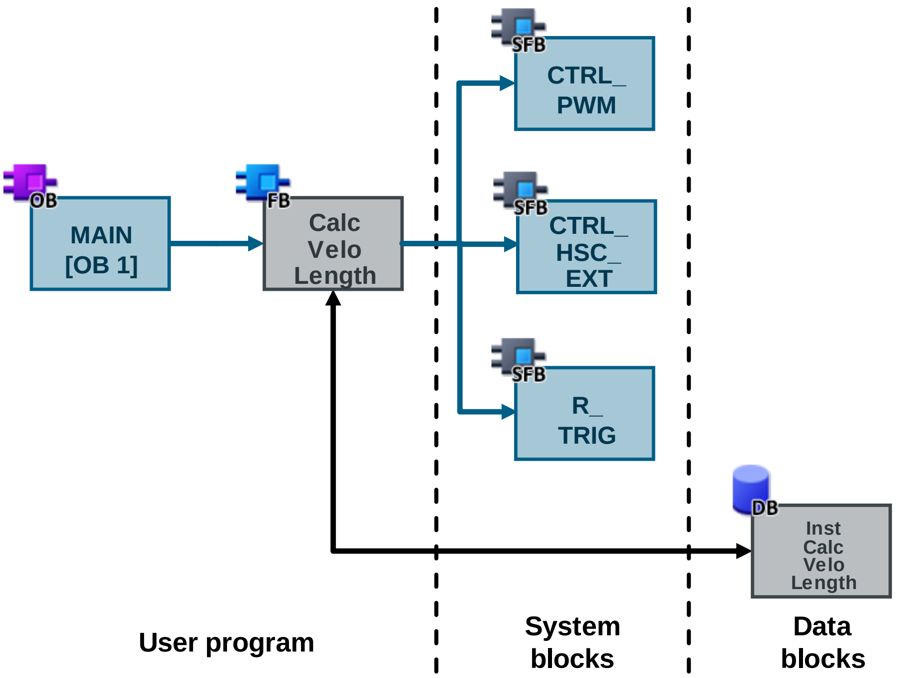


Figure 2-15



The "CalcVeloLength" FB is called up in the cyclic organization block.
It calls up the following system blocks:

- CTRL_PWM to perform pulse duration modulation
- CTRL_HSC_EXT to control the high-speed counter
- R_TRIG for positive edge evaluation of the capture input

The instance data block "InstCalcVeloLength" of the FB "CalcVeloLength" is also a multi-instance for the system FBs.

Depending on the configuration of the high-speed counter, one of the following system data types (SDT) is transferred to the "CTRL" interface of FB "CTRL_HSC_EXT":

- HSC_Count for "Count" mode
- HSC_Period for "Period" mode
- HSC_Frequency for "Frequency" mode

For the "Count" operating mode, the following static variables of the SDT "statHscCount" in the "CalcVeloLength" FBs are decisive:

Table 2-2: important parameters of the SDT "HSC_Count" (FB "CalcVeloLength.statHscCount")

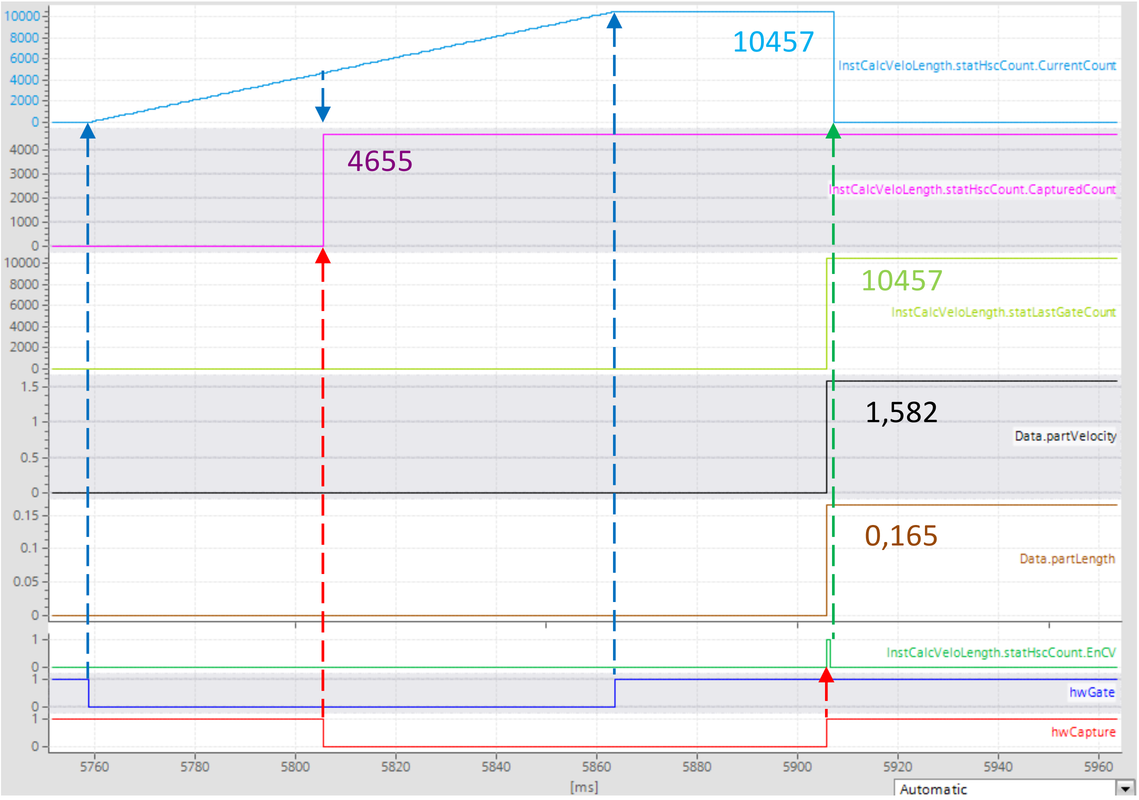
Name	Data type	Default value	Comment
CurrentCount	Dint	0	Outputs the current HSC value
CapturedCount	Dint	0	Outputs the counter value acquired at the specified input event
EnHSC	Bool	true	Must be true for the HSC to count pulses
EnCapture	Bool	true	Must be true in order for the "Capture" input to be evaluated
EnCV	Bool	false	Needed to set "CurrentCount" to "NewCurrentCount"

Name	Data type	Default value	Comment
			after evaluation
NewCurrentCount	Dint	0	Must be '0' to reset (synchronize) "CurrentCount" after evaluation

2.4 Operation

The Application Example is operated automatically via light barrier detection. For explanation, the following trace capture is used:

Figure 2-16



The light barriers are light-switching. If there is a negative edge at the "hwGate" gate input, the pulses are counted by means of a high-speed counter at "InstCalcVeloLength.statHscCount.CurrentCount". When the capture light barrier "hwCapture" is reached, the current counter value is stored in "InstCalcVeloLength.statHscCount.CaptureCount" (here 4655).
When the light barrier "hwGate" is exited, the count value "CurrentCount" is stopped (here 10457). If the object also leaves the second light barrier "hwCapture", the count is copied into the variable "InstCalcVeloLength.statLastGateCount" and the speed and the length of the object are calculated:

Data.partVelocity = distance / (captureCount" * pwmCycleTime)

Data.partVelocity = 73.66 mm / (4655 * 10 µs) ≈ 1.582 m/s

Data.partLength = partVelocity * gateCount * pwmCycleTime

Data.partLength = 1.582 m/s * 10457 * 10 µs ≈ 0.165 m/s

Finally, for synchronization, the bit "InstCalcVeloLength.statHscCount.EnCV" is set for one cycle. Then the count value "CurrentCount" of the high-speed counter is set to 0 and the next item can be measured.

2.4.1 Watch table

The "WatchTable" shows you all required data of the Application Example.

Figure 2-17

	i	Name	Address	Display format	Monitor value
1	// PWM				
2		"pwm1PulseDuration"	%QW1008	DEC	50
3		"pwm1CycleTime"	%QD1010	DEC	10
4		"pwm1Out"	%Q0.0	Bool	FALSE
5	// HSC				
6		"clockInput"	%I0.0	Bool	FALSE
7		"hwGate"	%I0.1	Bool	TRUE
8		"hwCapture"	%I0.2	Bool	TRUE
9		"hsc1CountValue"	%ID1000	DEC	0
10		"InstCalcVeloLength".statHscCount.CurrentCount		DEC	0
11		"InstCalcVeloLength".statHscCount.CapturedCount		DEC	4621
12		"InstCalcVeloLength".statHscCount.EnHSC		Bool	TRUE
13		"InstCalcVeloLength".statHscCount.EnCapture		Bool	TRUE
14		"InstCalcVeloLength".statHscCount.EnCV		Bool	FALSE
15		"InstCalcVeloLength".statHscCount.NewCurrentCount		DEC	0
16	// Calcuation				
17		"Data".lightBarrierDistance		Floating-point number	73.66
18		"InstCalcVeloLength".statLengthPerPulse		Floating-point number	0.01594027
19		"InstCalcVeloLength".statLastGateCount		DEC	10137
20		"Data".partVelocity		Floating-point number	1.594027
21		"Data".partLength		Floating-point number	0.1615866
22	// Status				
23		"Data".statusID		DEC	0
24		"Data".status		Hex	16#0000
25	// OB1 "Main" cycle time				
26		"Data".slowDownSwitch		Bool	FALSE
27		"Data".lastTime		Floating-point number	16#0000_000A_D1EF_66FC
28		"Data".lastCycleTime		Floating-point number	1.16024

2.4.2 HMI

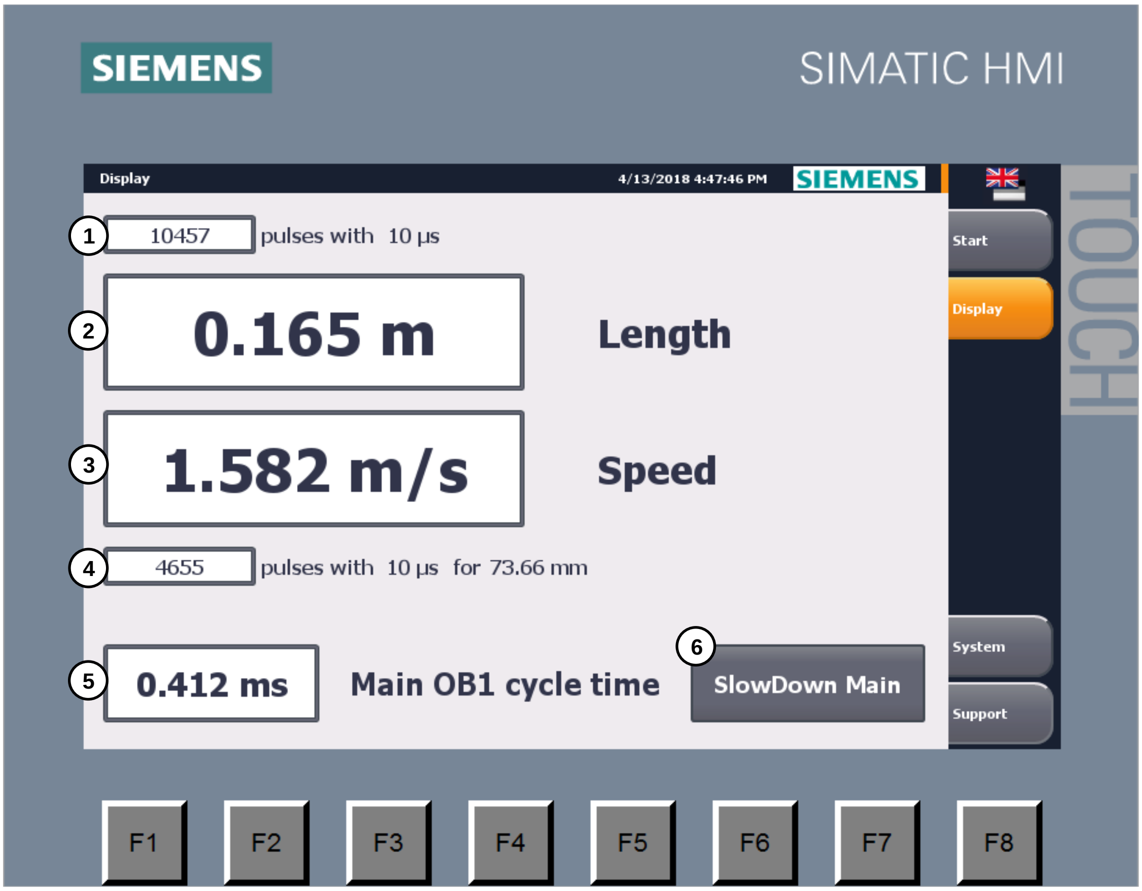
You can display the measured values using the SIMATIC HMI KTP 700 Basic PN or its simulation in the TIA Portal.

Note

For simulation in the TIA Portal, you must set the PC/PC interface (Set PC/PC Interface (32-bit)) in the Windows Control Panel as follows:

- Access point of the application: "S7ONLINE (STEP 7)"
- Interface Parameter Assignment Used: <Your network card> (Parameter assignment of your NDIS-CP with TCP/IP protocol (RFC-1006))
  (Parameter assignment of your NDIS-CP with TCP/IP protocol (RFC-1006))

Figure 2-18



In addition to the calculated length and velocity of the pencil, the number of pulses over a period of 10 µs is displayed.

The following variables are displayed:

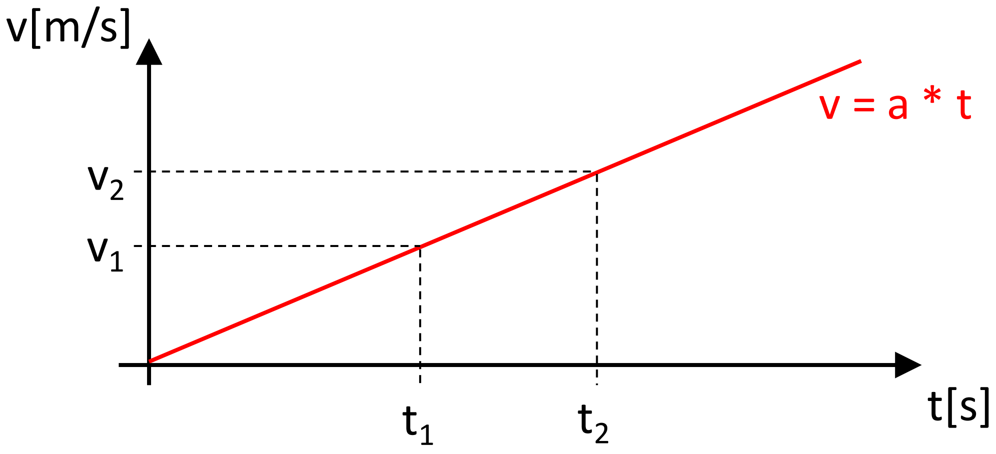
1. Measured number of pulses during the darkening of the "Gate" light barrier over a period of 10 µs (see PWM signal configuration -> Chapter 2.2.1)
2. Pencil length
3. Pencil speed
4. Measured number of pulses for the path ("distance" parameter -> Chapter 2.3) from the "Gate" light barrier to the "Capture" light barrier over a period of 10 µs (see PWM signal configuration -> Chapter 2.2.1) to calculate the speed
5. Cycle time of the calling OB1 "Main"
6. Button for extending the cycle time of the OB1 "Main" (as proof that the configured events of the high-speed counter function independently of the cycle time of the calling organization block)

2.5 Errorconsideration

2.5.1 Inclined plane

The pencil is accelerated evenly on the inclined plane. Therefore, the measured speed when the pencil tip reaches the capture light barrier (t_1) is lower than when the gate light barrier is exited (t_2). Thus, the measured length of the pencil is less than the actual length (l = v * t).

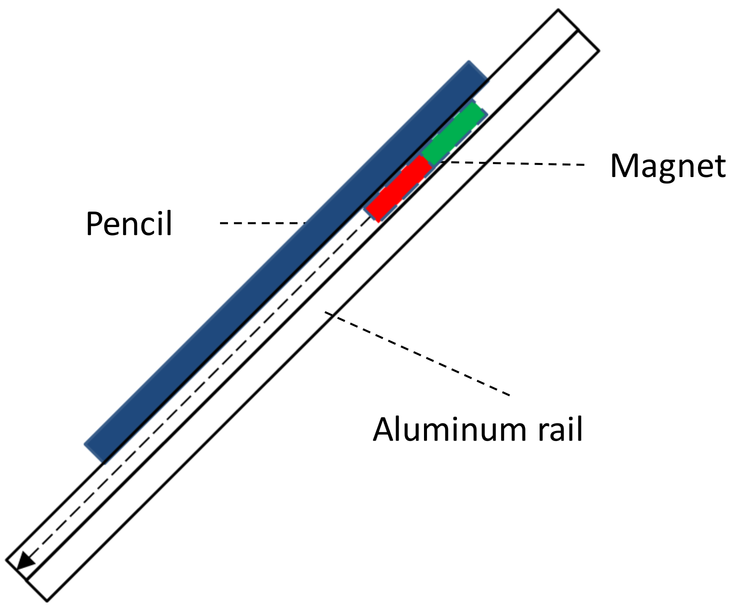
Figure 2-19



2.5.2 Eddy current brake

An eddy current brake is suitable for maintaining a constant speed of the pencil on the inclined plane. For this purpose, a small magnet is stuck to the pencil with adhesive tape. The magnet must fit in the guide of the aluminum rail, but does not touch it. The polar alignment (north-south) of the magnet is parallel to the guide in the direction of movement.

Figure 2-20



If the magnet is moved along the aluminum profile, a magnetic field is generated in the electrically conductive aluminum in accordance with Lenz's law, which counteracts that of the magnet. This results in an approximately constant speed of the pencil (\9\).

2.5.3 Acceleration by tensioning device

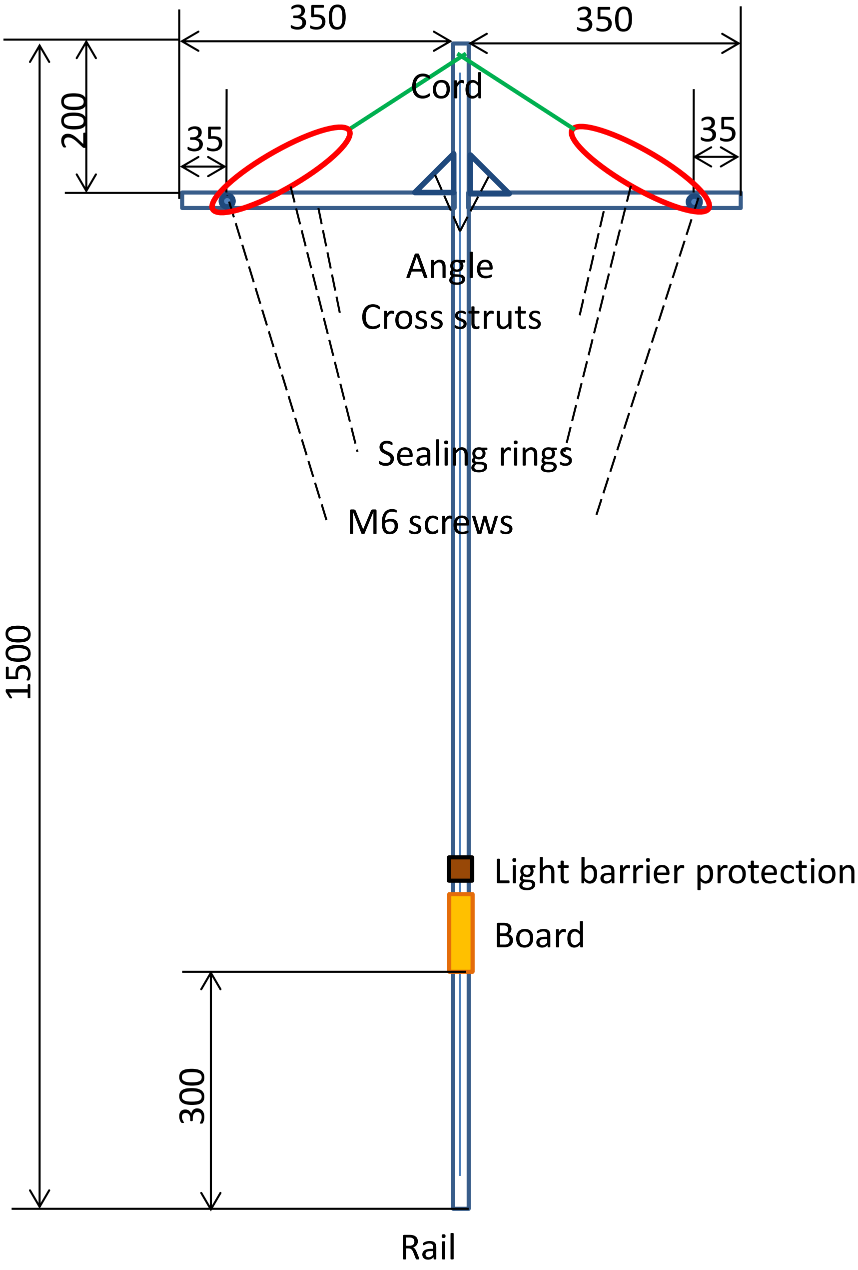
The tensioning device consists of a cross brace with two screws at the ends. A cord with two rubber sealing rings is tightened across the two screws. In this "bow", the slotted round wood peg is pulled like an "arrow" and converts the potential tension energy of the rubbers into kinetic energy upon release. This achieves a much higher speed of the pencil. The proportionate gravitational acceleration which also acts here has only a smaller influence on the speed measurement of the pencil due to the higher speed.

3 Useful information

3.1 Details on functionality

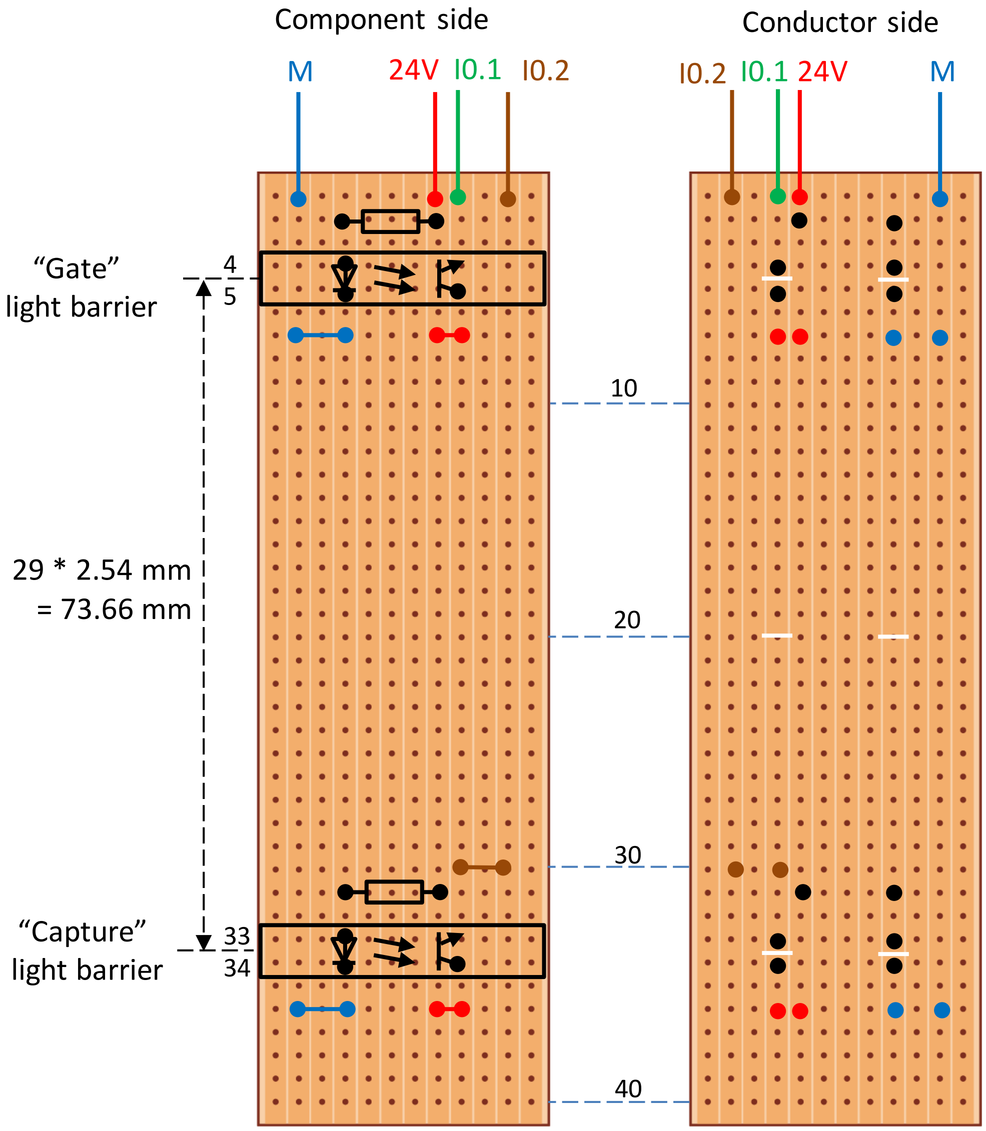
3.1.1 Dimensions

Figure 3-1



3.1.2 Strip board assembly

Figure 3-2



3.2 Basics

3.2.1 High-speed counters

The high-speed counters are internal hardware counters and thus much faster than software counters. The speed is limited by the inputs used.

Inputs

The SIMATIC S7-1200 offers the following inputs for the acquisition of signals via six configurable high-speed counters:

Table 3-1

Max. counting frequency	Inputs	Screen
1 MHz	Differential inputs (RS422/RS485) of the CPU 1217C (Eb.2 to Eb.5)	
200 kHz	Signal board inputs SB 1221 4DI 24V 200KHz SB 1221 4DI 5V 200KHz SB 1223 2DI/2DQ 24V 200KHz SB 1223 2DI/2DQ 5V 200KHz	
100 kHz*	Internal onboard inputs of all CPUs (Ea.0 to Ea.5)	
30 kHz	Other onboard inputs of CPUs 1212C to 1217C (from Ea.6 to max Eb.5)	

* Selected variant

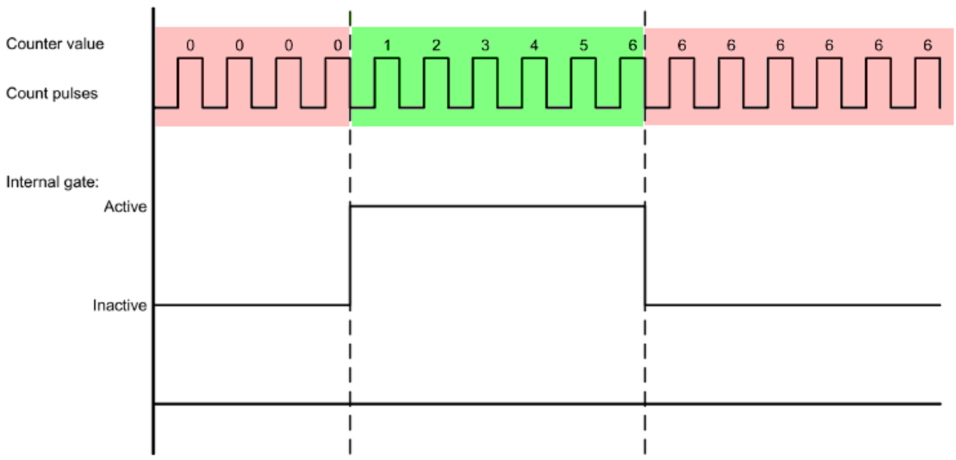
Note

An introduction to the S7-1200 can be found in the "SIMATIC S7 S7-1200 Automation System" manual (\3\).

Gate

The gate input enables the high-speed counter. Depending on the configuration, the gate input can block or enable counting. Pulses arriving at the count entrance are counted only when the gate is open.

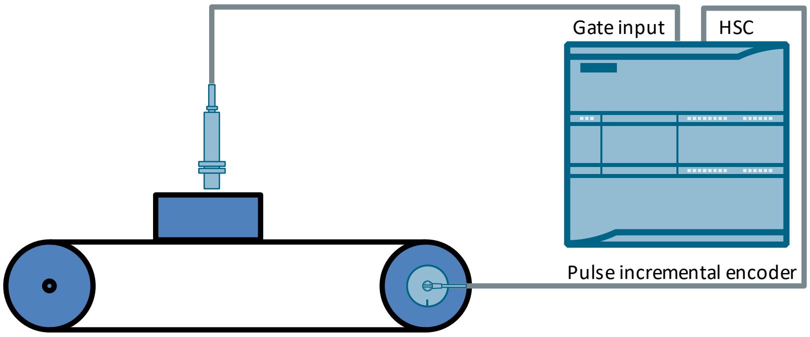
Figure 3-3



Application Example: Length measurement of objects on a conveyor belt

The pulses of an incremental encoder are counted as long as a light barrier (or a proximity switch) detects an object. From the number of pulses, the length of an object is calculated using a known travel length per pulse.

Figure 3-4: Determining length with HW gate



Note This use case is presented in detail in the Application Examples for High-Speed Counters (HSC) of the S7-1200 (\4\).

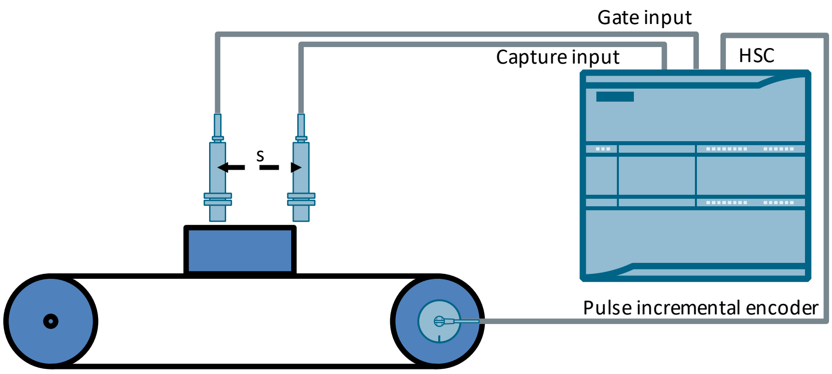
Capture

The capture input "Capture" saves the current counter value. Thus, while the gate is open, the continuous counter value can be recorded and written in "HSC_Count.CapturedCount" in the event of an external input edge. Evaluation can then be done separately and be temporally decoupled in the cyclic organization block.

Application Example: Speed and length measurement of objects

In addition to the detection of the length via the gate input, the speed is determined using the detection input and the distance of the light barriers.

Figure 3-5: Determine length and speed with HW-Gate and HW-Capture



$v = s / t_{Capture}$

$t_{Capture} = n_{Capture} * T_{Pulse}$

$v = s / (n_{Capture} * T_{Pulse})$

$l = v * t_{Gate}$

$t_{Gate} = n_{Gate} * T_{Pulse}$

$l = v * n_{Gate} * T_{Pulse}$

$l = s * n_{Gate} / n_{Capture}$

Note

The prerequisite for this is a constant speed of movement and the length of the object must be at least equal to the distance between the light barriers!

3.2.2 PWM (Pulse Width Modulation)

The SIMATIC S7-1200 has four configurable pulse generators that can output the following:

- Pulse trains (fixed duty cycle, varying period) or
- PWM signals (fixed period, varying duty cycle)

The speed is limited by the outputs used.

Outputs

The SIMATIC S7-1200 offers the following DC outputs for pulse generation:

Table 3-2

Max. pulse rate	Inputs	Screen
1 MHz	Differential outputs (RS422/RS485) of the CPU 1217C (Aa.0 to Aa.3)	
200 kHz	Signal board outputs SB 1222 4DQ 24V 200KHz SB 1222 4DQ 5V 200KHz SB 1223 2DI/2DQ 24V 200KHz SB 1223 2DI/2DQ 5V 200KHz	
100 kHz*	Onboard outputs of • CPUs 1211C – 1215C (Aa.0 to Aa.3) • CPU 1217C (Aa.4 to Ab.1)	
20 kHz	Onboard outputs of • CPU 1212C (Aa.4 to Aa.5) • CPUs 1214C – 1215C (Aa.4 to Ab.1)	

* Selected variant

Note

An introduction to the S7-1200 can be found in the "SIMATIC S7 S7-1200 Automation System" manual (\3\).

For CPU versions with relay outputs, you must install a digital signal board (SB) to use the pulse outputs.

4 Appendix

Industry Online Support

Do you have any questions or need assistance?

Siemens Industry Online Support offers round the clock access to our entire service and support know-how and portfolio.

The Industry Online Support is the central address for information about our products, solutions and services.

Product information, manuals, downloads, FAQs, application examples and videos – all information is accessible with just a few mouse clicks:
https://support.industry.siemens.com

Technical Support

The Technical Support of Siemens Industry provides you fast and competent support regarding all technical queries with numerous tailor-made offers – ranging from basic support to individual support contracts. Please send queries to Technical Support via Web form:
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- Repair services
- On-site and maintenance services
- Retrofitting and modernization services
- Service programs and contracts

You can find detailed information on our range of services in the service catalog web page:
https://support.industry.siemens.com/cs/sc

Industry Online Support app

You will receive optimum support wherever you are with the "Siemens Industry Online Support" app. The app is available for Apple iOS, Android and Windows Phone:
https://support.industry.siemens.com/cs/ww/en/sc/2067

4.1 Links and Literature

Table 4-1

No.	Topic
\1\	Siemens Industry Online Support https://support.industry.siemens.com
\2\	Link to the entry page for the Application Example https://support.industry.siemens.com/cs/ww/en/view/109754525
\3\	SIMATIC S7-1200 Automation System System Manual https://support.industry.siemens.com/cs/ww/en/view/109764129
\4\	S7-1200: Application Examples for high-speed counter https://support.industry.siemens.com/cs/ww/en/view/109742346
\5\	Basic Controller: Technology Integrated Measuring length and speed with SIMATIC S7-1200 https://www.youtube.com/watch?v=eB-k6HW58xA
\6\	Updates for STEP 7 V15.1 and WinCC V15.1 https://support.industry.siemens.com/cs/ww/en/view/109763890
\7\	Firmware update for CPU 1211C, DC/DC/DC, 6DI/4DO/2AI https://support.industry.siemens.com/cs/ww/en/view/107247170
\8\	Optek forked light barrier OPB815L, phototransistor output, screw mounting, 4 pin https://de.rs-online.com/web/p/gabel-lichtschranke/1944024/
\9\	WIKIPEDIA: Lenz's law https://en.wikipedia.org/wiki/Lenz%27s_law

4.2 Change documentation

Table 4-2

Version	Date	Change
V1.0	06/2018	First edition
V1.1	07/2019	Update TIA Portal V15.1