AP9600C
Absolute Rotary Encoder

Product data

Features

- Highly miniaturized encoder
- Differential inductive sensing principle
- Insensitive to magnetic interference fields
- Robust against oil, water, dust, particles
- Profile-height encoder + scale < 5 mm
- Absolute position upon power-on

Applications

- Robotics
- Electric motors
- Rotary tables

Key Specifications

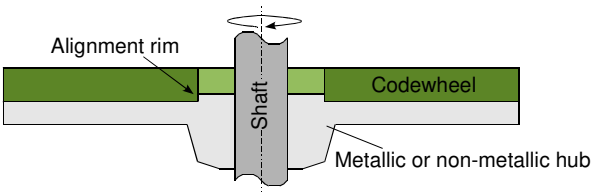
Output format.....SSI with RS422 line driver
Resolution.....up to 23 bits
Maximum speed .....up to 23'000 RPM
Airgap .....up to 0.5 mm
Supply.....5 V, 70 mA
Temperature .....-20 to 100°C

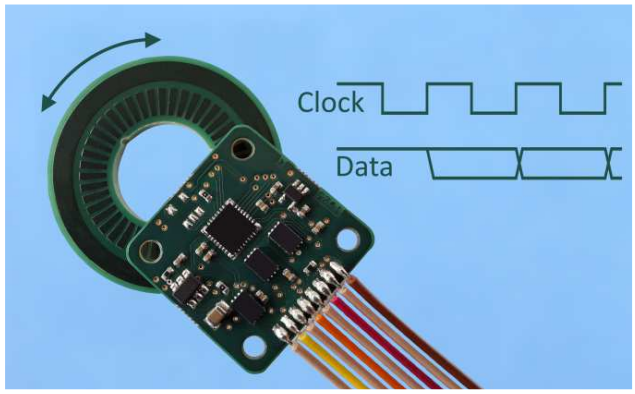
Description

The AP9600C absolute encoder kit consists of an encoder and a codewheel (Fig. 1). The encoder consists of a printed circuit board with a 2-track encoder-chip AP5603L on the frontside and a microcontroller and linedrivers on the backside. The microcontroller reads out the encoder-chip, calculates the absolute position and converts this into a binary SSI code. The output is a Serial Synchronous Interface SSI with an RS422 line driver. The codewheel is a PCB with passive copper strips arranged in 2 tracks (Fig. 8 and Table 5).

Maximum speed
The maximum speed of the encoder is user-programmable or can be programmed ex-factory according to Table 2.

Codewheel
The codewheels are shown in Fig. 7 and are selected in Table 5. The codewheel may be mounted on a hub, using a rim for accurate positioning in front of the encoder.





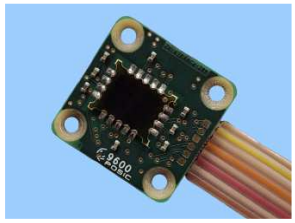
Encoder assembly
The encoder has 4 screwholes and is delivered with 4 spacers (Fig. 7) that allow an easy assembly.

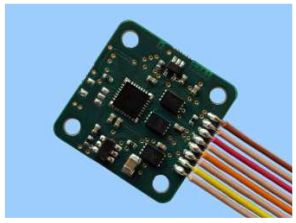
Encoder cable and connector
The encoder is optionally equipped with a flat twisted-pair cable of pitch 1.27 mm and an 8-pin DIN 41651 connector. The cable length and the connector type are selected in Tables 7 and 8.

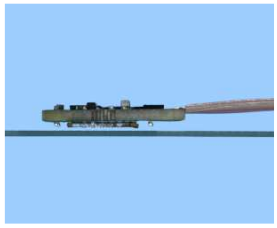
Encoder programming
The Evaluation and Programming Tool (EPT) including an interface board and the ASSIST software is available for the evaluation, linearization and programming of the encoder.

Self-calibration
With the Evaluation & Programming Tool, a self-calibration can be carried out in order to compensate eccentricity non-linearities.

3D models
3D STEP models of the encoder, the codewheel and the distance rings are available on www.posic.com.


Frontside with encoder-chip


Backside with microcontroller


Profile height Encoder + Scale < 5 mm

Specifications

Recommended Operating Conditions

Parameter	Symbol	Remark	Min	Typ	Max	Unit
Supply voltage	VDD		4.75	5.0	5.25	V
Startup time	T_{start}	Codeweel must be static	100			ms
Operating Temperature	T_A		-20		100	°C
SSI Clock frequency	$F_{SSIclock}$		0.2	1	1.1	MHz
Airgap*	Z			0.2	0.5	mm
Eccentricity	ΔY				± 0.1	mm
Radial play	ΔY				± 0.01	mm
Axial play	ΔZ				± 0.1	mm

* For optimal performance, an airgap of 0.2 mm is recommended.

Electrical Characteristics

Electrical characteristics over recommended operating conditions, typical values at VDD = 5.0 V, T_A = 25°C.

Parameter	Symbol	Remark	Min	Typ	Max	Unit
Supply current	IDD	No load	55	70	85	mA
Driver differential output voltage	V_{OD}	R_L = 100 Ω (1)	3.0	3.8		V
Driver common mode output	V_{OC}	R_L = 100 Ω (1)			3.2	V
Driver short circuit output current	I_{SC}	See (1)			± 450	mA
Differential input voltage threshold	V_{TH}	-7V < V_{CM} < 12V	-200		-50	
Rise time, fall time	t_r, t_f	C_L = 47 pF (1)		6	15	ns

(1) See EIA Specification RS-422 for exact test conditions.

Encoder Characteristics

Encoder characteristics under nominal operating conditions with codewheel TPCA21-044.

Parameter	Symbol	Remark	Min	Typ	Max	Unit
Resolution		SSI data format		23		Bits
		Noise-free resolution with: - Max speed 10 RPM - Max speed 100 RPM - Max speed 1'000 RPM		 20 19 15		Bits
Accuracy		After calibration*		0.1		°m
Repeatability		Expressed in LSB of the noise-free resolution		1		LSB
Position sample latency		Physical position to start of SSI transmission			3	µs

* Excluding eccentricity error

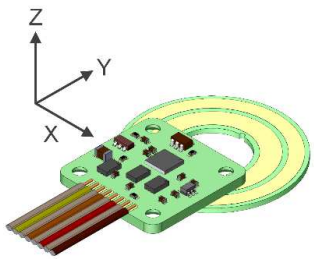


Fig. 1 Coordinate system XYZ.

Definitions

Airgap	Distance between encoder and scale in Z-direction (Fig. 1)
°e	Electrical degree (1 period = 360°e)
°m	Mechanical degree (1 revolution = 360°m)
SSI	Serial Synchronous Interface
Period	Center-to-center distance between adjacent copper strips

SSI Description

Connections

The SSI (Synchronous Serial Interface) uses fully RS-422 compliant 5V differential transmission channels (Fig. 2). The clock input is terminated with a 120Ω resistor inside the encoder. For reliable transmission on long cables, the user has to terminate the data lines on the controller side with a resistor corresponding to the characteristic impedance of the used cable. The balanced characteristic impedance of a .05" AWG28 7/36 twisted pair flat cable is generally in the range of 120Ω.

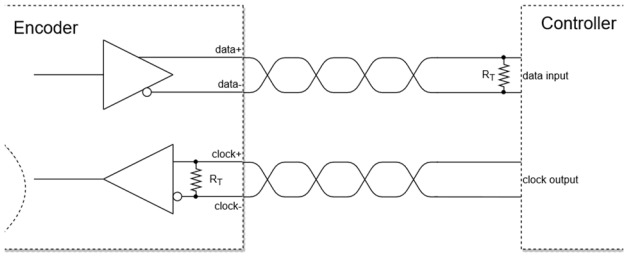


Fig. 2 SSI connections.

Transmission protocol

Bit nr.	30	29	28	…	8	7	6	5	4	3	2	1	0
Description	nE	Pos(22:0)					nW	CRC(5:0)					

Bit	Data field	Description
30	nE	No Error 1: Position data is valid 0: Position data is not valid
29:7	Pos(22:0)	Position, left aligned, transmitted MSB first
6	nW	No Warning 1: Position data is valid 0: Position data is valid, but some operational conditions may be close to the limits and the position data may be out of specification
5:0	CRC(5:0)	Cyclic Redundancy Check. The polynomial for the CRC calculation is x^6+x+1. The initial value is 0 and the bits are transmitted inverted.

Normal transmission

A single data frame consist of 31 bits (Fig. 3). On the leading clock edge sent by the controller, the encoder fetches the latest position data. This data is made available on the subsequent rising edges of the incoming clock signal. Once all 31 bits are sent, the data output is forced to 0 until the end of the clock time-out period. The output is forced to 1 when the time-out expires. The encoder is then ready for the transmission of new position data.

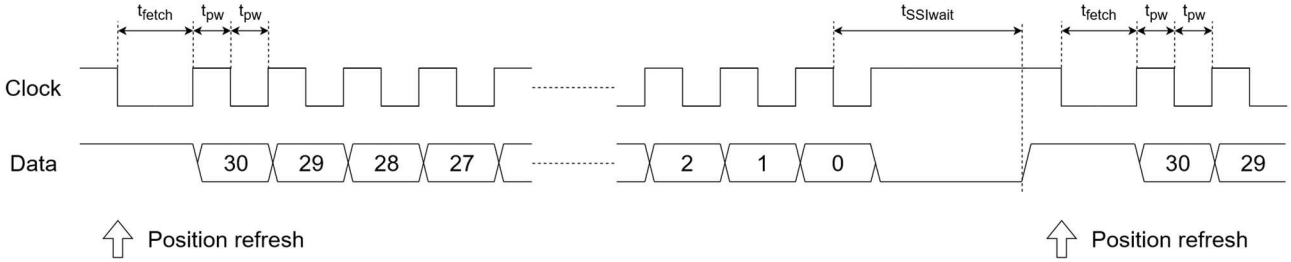


Fig. 3 SSI frame timing diagram for normal transmission.

Partial transmission

It is not mandatory to read the full 31 bit data frame. If only the first part of the frame is of interest for the controller, it can stop the transmission of the frame by holding the clock line high for a period exceeding the clock time-out. At the next falling edge of the clock, the position data will be refreshed and a new data frame started. Fig. 4 shows an example where only the first 8 bit of the frame are read.

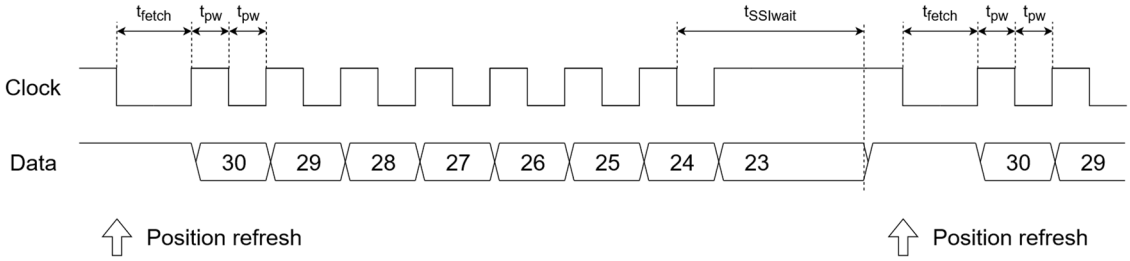


Fig. 4 SSI frame timing diagram for partial transmission, only the initial 8 bits are transmitted.

Re-transmission
The encoder also implements the SSI multiple transmission mode: if an additional clock cycle is present before the expiration of the clock time-out at the end of the message, the position information is not updated and the exact same message is repeated (Fig. 5).

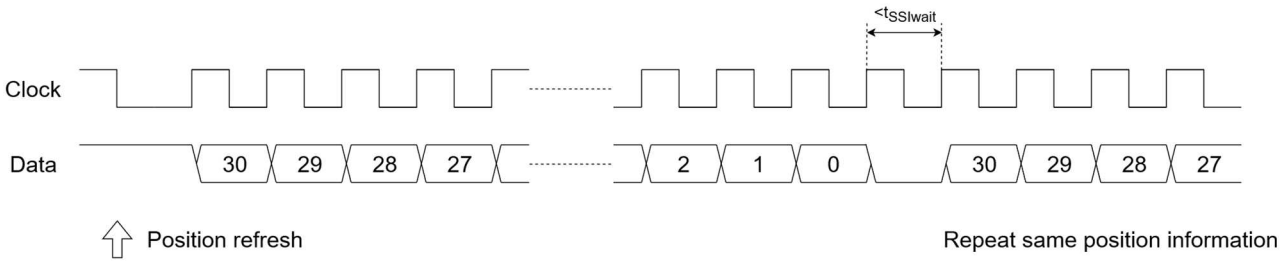


Fig. 5 SSI frame timing diagram for re-transmission of the previous data.

SSI timing characteristics

Parameter	Symbol	Remark	Min	Typ	Max	Unit
SSI Wait time	$t_{SSIwait}$	Time between SSI-frames	19	20	21	µs
Position refresh time	$t_{refresh}$			2	3	µs
Input clock position fetch time	t_{fetch}		450			ns
Input clock pulse width	t_{pw}		100			ns

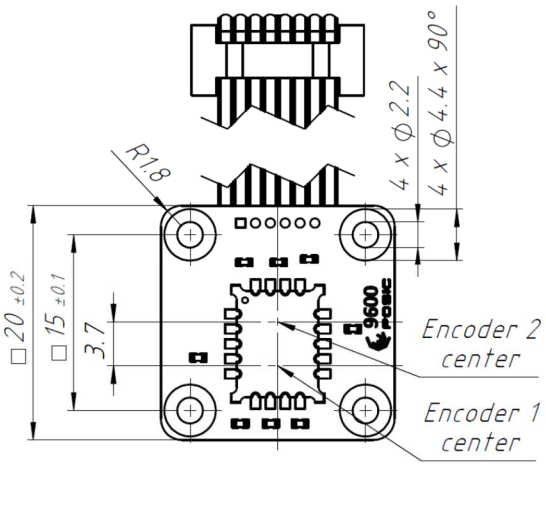
Self-Calibration

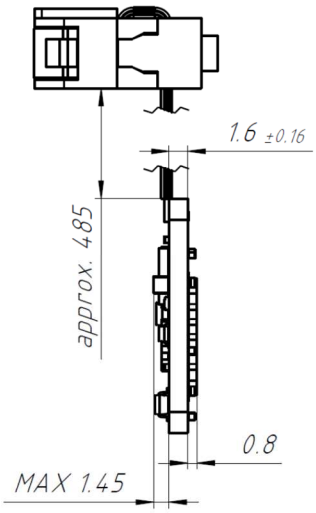
The AP9600C encoder can carry out a self-calibration when it is connected to the Evaluation & Programming Tool EPT002 and the associated ASSIST software:

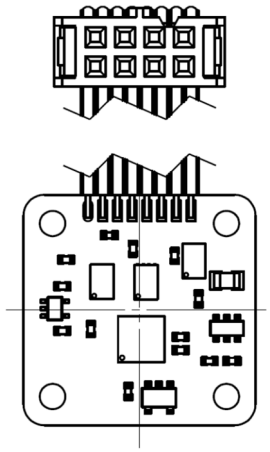
1) Start the ASSIST software and go to the Linearization window
2) Select Self Calibration and start the calibration measurement
3) Slowly rotate the codewheel in one direction until the software indicates that the calibration has been completed
4) The ASSIST software calculates a LookUp Table (LUT) based on the measured data and stores the LUT in the encoder's non-volatile memory.

The Self-Calibration needs no reference encoder and it is not required to rotate at a constant speed.
The encoder's non-volatile memory is re-programmable and therefore the self-calibration can be carried out at regular intervals.

Technical drawings







Pin	SSI
1	5V Supply
2	Ground
3	Clock-
4	Clock+
5	Data-
6	Data+
7	Not Connected
8	Not Connected

Fig. 6 Dimensions and pin-out of AP9200 encoder. Encoder 1 center must be aligned to Track 1 center (Readout Radius RR1 in Fig. 8) and Encoder 2 to Track 2 (RR2 in Fig. 8). The height of the components on the backside of the encoder is 1.45 mm maximum. Plastic distance rings of 1.6 mm height are optionally delivered with the encoder in order to mount the encoder on a flat surface without the electronic components touching the mounting-surface.

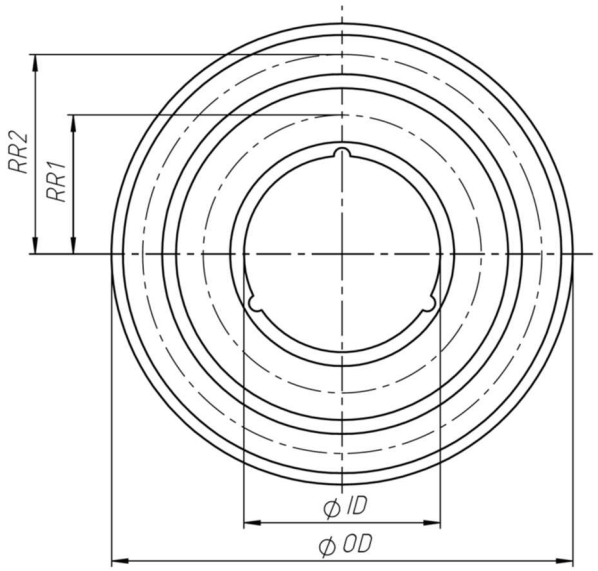


Fig. 8 Dimensions for codewheels for the AP9600C encoder. RR = Readout Radius. Encoder 1 center must be aligned to RR1 and Encoder 2 center to RR2.
Values for TPCA21-044:
ID = 12 mm OD = 28.2 mm
RR1 = 8.5 mm RR2 = 12.2 mm
The half-holes at the inner diameter are for alignment purposes and have a diameter of 1 mm.

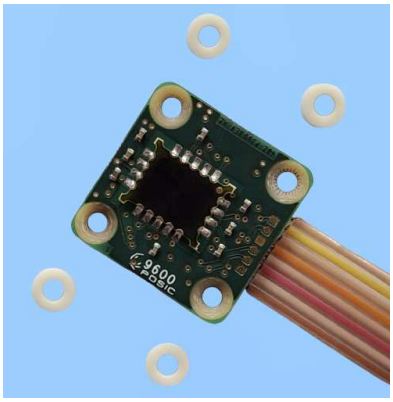


Fig. 7 Four plastic distance rings of 1.6 mm thickness are optionally (Table 6) delivered with each encoder in order to mount the encoder on a flat surface and avoid that the components on the backside touch the mounting-surface. The height of the components is 1.45 mm maximum (Fig. 6).

Ordering information

Ordering code: AP9600C-ABBCCD-EEEEE-F-GGG-HH

A	Orientation	Table 1
BB	Maximum speed	Table 2
CC	Interface	Table 3
D	Look-Up Table	Table 4
EEEEE	Codewheel	Table 5
F	Spacers	Table 6
GGG	Cable	Table 7
HH	Connector	Table 8

Table 1: Orientation. Arrows indicate direction of movement of the scale with increasing position.

A	Orientation
0	Not progr. (default 0°)
3	0°
5	180°

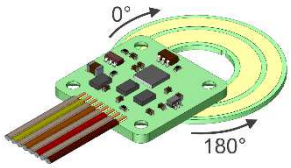


Table 2: Maximum speed with codewheel TPCA21-044

BB	Max speed (RPM)	Noise-free resolution (bits)*	Typical filter-delay (ms)
00	Not programmed		
01	13	20	26
02	26	20	13
03	52	20	6.4
04	104	19	3.2
05	207	18	1.6
06	414	17	0.8
07	828	16	0.4
08	1’656	15	0.2
09	3’313	14	0.1
21	6’625	13	0 at constant speed
22	13’250	13	
23	26’500	13	

* At nominal airgap 0.2 mm

Table 3: Interface

CC	Interface
00	Not programmed (default SSI Binary)
01	SSI, Binary

Table 4: Look-Up Table (LUT)

D	Look-Up Table programmed in OTP
0	Not programmed
1	LUT according to codewheel specified in Table 5
8	Custom LUT, to be specified

Table 5: Codewheel (Fig. 8)

EEEEE	OD (mm)	ID (mm)	# Periods
00000	No Codewheel		
21044	28.2	12.0	44

Table 6: Distance rings (Fig. 7)

F	Distance rings
0	No distance rings
1	Including 4 distance rings

Table 7: Cable

GGG	Flat twisted pair cable
000	No cable
050	Length 50
100	Length 100 cm

Cable temperature range: -20 to 80°C.

Table 8: Connector

HH	Connector
00	No connector
04	8-pin connector DIN 41651 (Fig. 6)