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Energy In Motion

ENGINEERING PUBLICATION
MOTION CONTROL DIVISION

PRODUCT: SGDA, SGDB **SUBJECT:** Absolute Encoder

CATEGORY: *Prod. Note*
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SUMMARY: Attached is a description for how Yaskawa absolute encoders operate.

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Yaskawa Absolute Encoders

I Why use an Absolute Encoder?

II The two types of Absolute Encoders

1. The 15-bit Encoder.
Primarily on the larger Sigma motors (SGMG & SGMS)

a. 8192 pre quadrature pulses/rev.
32768 post quadrature pulses/rev (15-Bit)

b. Wire scheme on MS-connectors:

PIN	Signal Name	Color Code
A	Phase A	Blue
B	*Phase A	White/Blue
C	Phase B	Yellow
D	*Phase B	White/Yellow
E	Phase C	Green
F	*Phase C	White/Green
G	0V-Power	Black
H	+5VDC-Power	Red
J	Frame Ground	Green/Yellow
K		
L		
M		
N		
O		
P		
R	Reset	White/Gray
S	0V-Batt	White/Orange
T	+3.6V-Batt	Orange

c. Electrical characteristics:

- Each Phase is an RS-422 type (~±4.5VDC) Line Driver.
- The Encoder memory is battery backed. Recommend battery is a 3.6V, lithium battery at 2000mAh. The encoder pulls about 3µA from the battery when the encoder is powered off.

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2. The 12-bit Encoder.
Primarily on the Smaller Sigma motors (SGM & SGMP), but available as on special order on larger.

a. 1024 pre quadrature pulses/rev.
   4096 post quadrature pulses/rev (12-Bit)
b. Wire scheme:

MS-connectors(Option-M):

PIN	Signal Name	Color Code	PIN	Signal Name	Color Code
A	Phase A	Blue	K	Phase S	Purple
B	*Phase A	White/Blue	L	*Phase S	White/ Purple
C	Phase B	Yellow	M		
D	*Phase B	White/Yellow	N		
E	Phase C	Green	O		
F	*Phase C	White/Green	P	Capacitor Reset	Gray
G	0V-Power	Black	R	Reset	White/Gray
H	+5VDC-Power	Red	S	0V-Batt	White/Orange
J	Frame Ground	Green/Yellow	T	+3.6V-Batt	Orange

Nylon AMP® connectors (Standard)

PIN	Signal Name	Color Code	PIN	Signal Name	Color Code
1	Phase A	Blue	10	Phase S	Purple
2	*Phase A	White/Blue	11	*Phase S	White/ Purple
3	Phase B	Yellow	12	Capacitor Reset	Gray
4	*Phase B	White/Yellow	13	Reset	White/Gray
5	Phase C	Green	14	0V-Batt	White/Orange
6	*Phase C	White/Green	15	+3.6V-Batt	Orange
7	0V-Power	Black			
8	+5VDC-Power	Red			
9	Frame Ground	Green/Yellow			

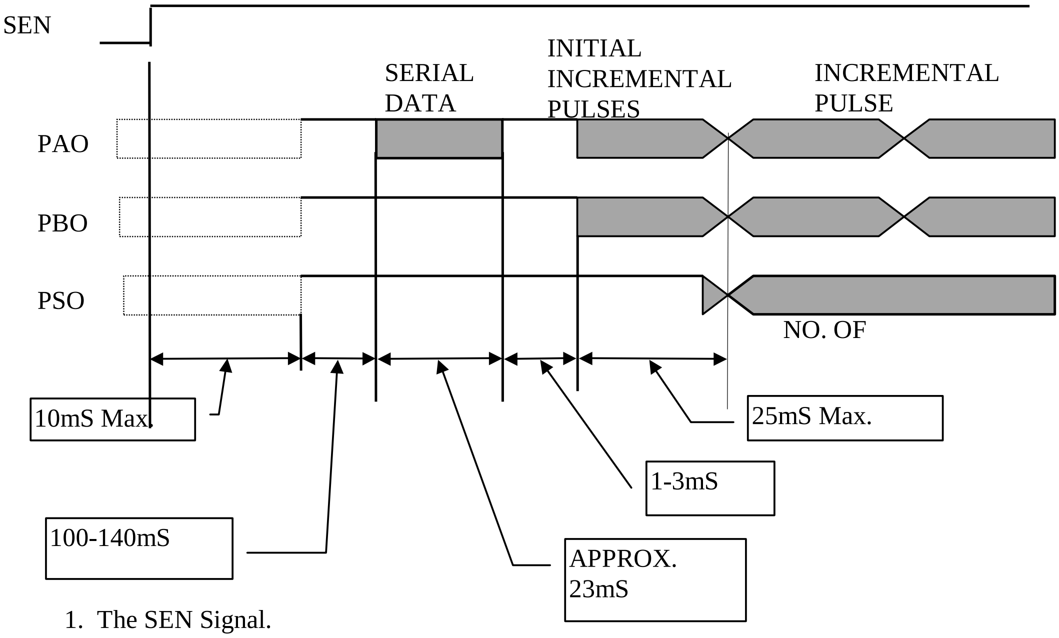
c. Electrical characteristics:
- Each Phase is an RS-422 type (~±4.5VDC) Line Driver.
- The Encoder memory is battery backed. Recommend battery is a 3.6V, lithium battery at 2000mAh. The encoder pulls about 3µA from the battery when the encoder is powered off.

d. Note the addition of an S-Channel. This channel constantly transmits The status and position of the encoder as standard ASCII characters. What is required to capture this information is an RS-422 (RS-232) port and a software development package behind this port with the power to:
- strip away characters
- change ASCII numeric characters, to usable numbers so math can be done.

III The absolute encoder objective on power-up:

- Tell the Servopack the encoder's state.
- Tell the host control the state and position.

Below is the timing diagram of the signals from our absolute encoders. an explanation will follow.



1. The SEN Signal.

The SEN signal does nothing more than synchronize the encoder power-up with the servopack (and host) timing.

The Servopack must know the state of the absolute encoder. The only way to get it is from the encoder itself. **The encoder transmits it's status via serial information over the A-Channel when it is first powered up**. Therefore, the encoder must be turned on when the servopack is ready to receive this information. **The SEN Signal will turn on the encoder and (at the same time) tells the servopack to get ready to receive this information.**

The SEN signal may be initiated by the servopack itself on power-up or it can be done remotely by the host controller. The host may give the SEN signal not only to synchronize the servopack and encoder, but to also get ready to receive this information itself.

2. The Serial Data:

In the case of the 12-bit Absolute encoder, the serial data from the A-Channel tells the servopack (and/or the host) the state of the absolute encoder. The 15-bit only transmits if it's status is good, otherwise the servopack will just give a general absolute encoder alarm.
Again, in the case of the 12-bit, the encoder will transmit either an alarm code or the number of revolutions in standard ASCII format. If the Servopack receives an alarm code, it will not allow the motor to power-up regardless of the SVON input state.
Also, for an alarm state such as a missing or low battery, the servopack (or host in this case) will not know of the alarm until power is cycled. This is true even if the battery was replaced while the encoder was still powered. This is not to imply the encoder will lose it's memory. These encoders have a super capacitor used to back up the memory. This will warn of a weak battery or a faulty battery connection.
It must be emphasized that when the encoder is <u>not in an alarm state</u> only the number of revolutions (from the setup point) are transmitted serially, not where it is within a revolution. The exact quadrature encoder count (relative to the marker pulse) can be obtained from the "initial incremental pules."

3. Initial incremental pulses:

These are pulses sent from both the A and the B Channel and will give you the motor's shaft position in quadrature encoder counts relative to the marker pulse.

Example

If the Servosystem is powered up (and has a 12-bit encoder) and the encoder transmits to the host "P+1234" then the host counts 1285 quadrature initial incremental pulses are counted.

$$+1234 \times 4096 - 1285 = 5053179\, pulses$$

Note how the initial incremental pulses are subtracted. The initial incremental pulses counted is the position the encoder is at, counting in the negative direction from the marker pulse.

If the information transmitted from the host was "P-1234" and the same number initial incremental pulses as in the above example are counted then the position will be:

$$-1234 \times 4096 - 1285 = -5055749\, pulses$$

Note: Although our Servopacks divide (or scale) under normal operation, the absolute information is not scaled. ***The "initial incremental pulses are sent at full encoder resolution.***

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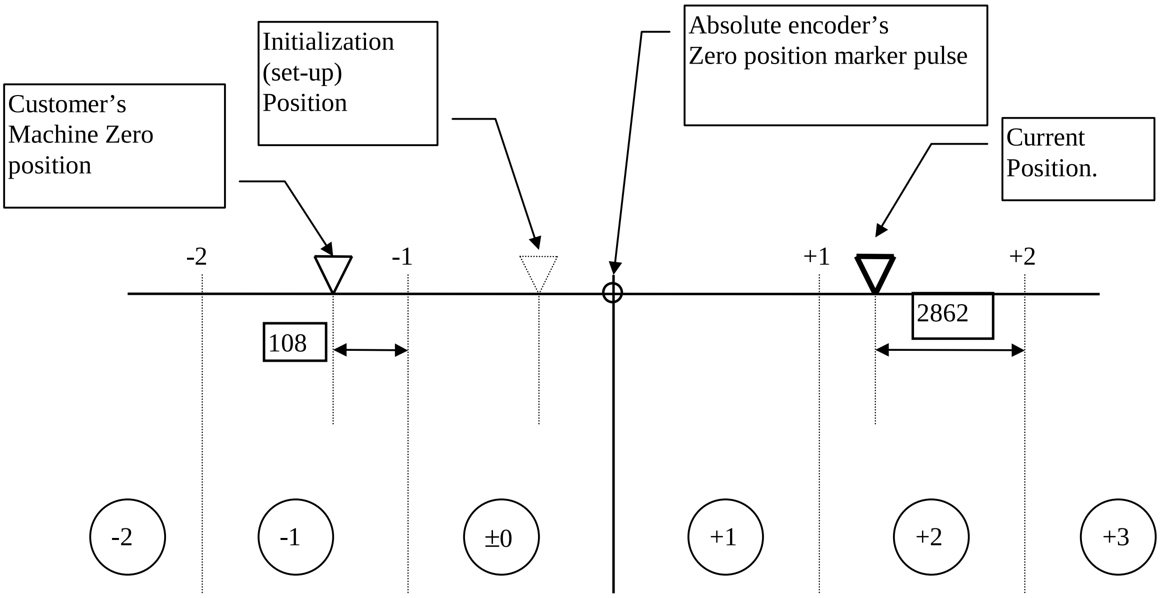
Below is a diagram of what the A-Channel serial data and initial incremental pulses means relative to the encoders position:



The values in the circles are the serial position data displayed in that zone. The values in the boxes are the number of quadrature pulses in the negative direction from the marker pulse.
The customer's machine zero position, is an offset stored in a host controllers memory. It should be read in after encoder set-up and the machine was physically moved to it's home position.
The customer's machine zero position should never be confused with the initialization (set-up) position. The initialization position is the point were the encoder's reset lines were shorted after the first power-up.
Once a zero position has been memorized, the current position is (as far as the machine is concerned) calculated as follows:

Current position - Saved machine zero position = Actual Position
(All done in ***unscaled*** quadrature encoder pulses)

So for the above illustration:
= [+2 x 4096 -2862] - [-1x4096 - 108]
= [5330] - [-4204]
= 9534 quadrature encoder pulses from machine zero point

Since Sigma and All Digital Yaskawa Servopacks have user selectable encoder division, applications are commonly done in user (reference) units rather than encoder pulses.
So in this case, if there are 1000 quadrature user units per motor revolution:

= 9534 quadrature encoder pulses from machine zero point.

$$\Leftrightarrow \frac{9534}{4096} \times 1000 = 2327.636719 \approx 2328$$ user units from machine zero point.

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4. The 12-bit encoders S-Channel.
The S-channel of the 12-bit Absolute encoder is another way of getting position data and encoder status. The major difference between the information form the S-channel and that of the A-channel (on the 12-bit only) is how the information is formatted, and how often this information is available.

The S-channel transmits information every 40mS. The host controller can monitor the position, status, or alarm state. This information is transmitted in standard ASCII alphanumeric at the following communications parameters:

Baud Rate	9600
Start Bit	1 bit
Stop Bit	1 bit
Parity	Even
Character code	ASCII 7-bit code
Data Format	13 Characters

Possible Alarms:
There are five absolute encoder alarms: Overspeed, Encoder Sensor, Battery, Checksum, and Back up. Each are explained in below:

Overspeed:
Occurs when the rotation speed is greater than 400rev/min during power-up

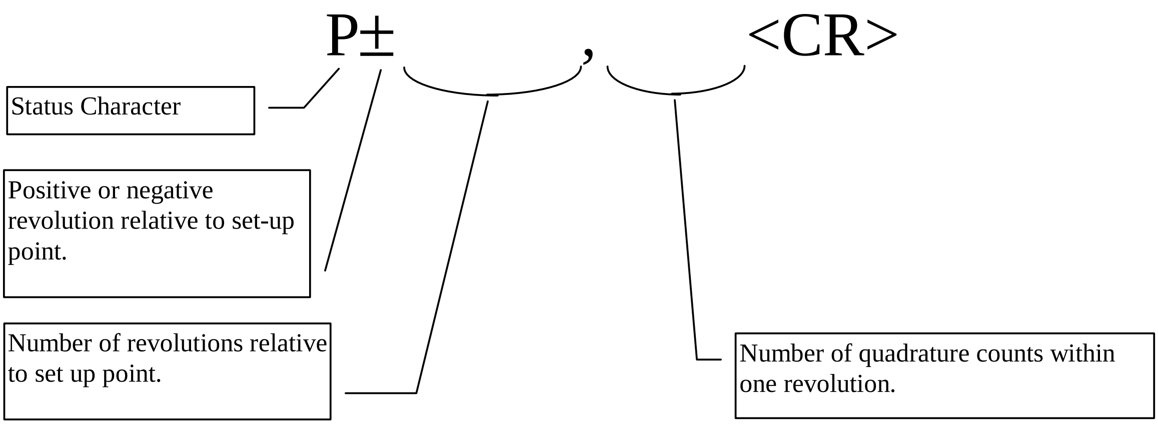
Encoder Sensor:
Occurs when there is a hardware error with the encoder's sensor circuitry.

Battery:
Occurs when the back-up voltage (battery) is not connected or is low.

Checksum:
Encoder memory is has invalid information, therefore position information transmitted (on S-Channel or A-Channel) is invalid.

Back-up:
The super capacitor is discharged Capacitor is used to backup encoder memory and keep position for 2 days without back up voltage (battery).

The standard transmission looks like the following:

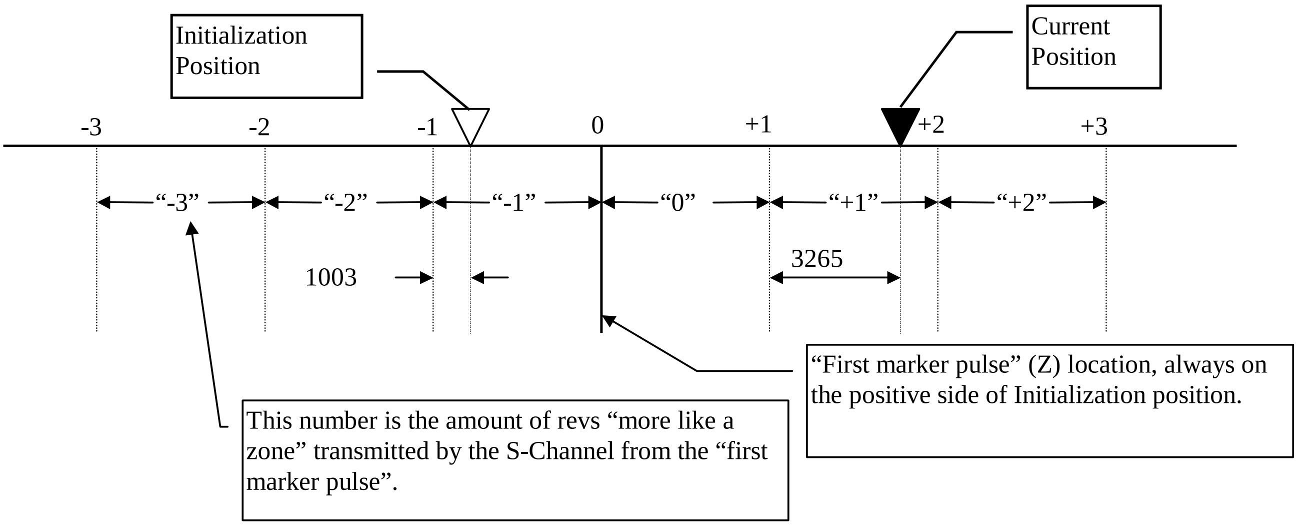


With the exception of the first character, the numeric information is straight forward. Below is a chart that shows the possible errors that occur, and what the first character will be under that condition.

	Alarm Type				
Character	Over Speed @ Power-up	Encoder Sensor	Battery	Memory Checksum	Capacitor Back-up.
A					✔
B				✔	
C				✔	✔
D			✔		
E			✔		✔
F			✔	✔	
G			✔	✔	✔
H		✔			
I		✔			✔
J		✔		✔	
K		✔		✔	✔
L		✔	✔		
M		✔	✔		✔
N		✔	✔	✔	
O		✔	✔	✔	✔
P	✔				
Q	✔				✔
R	✔			✔	
S	✔			✔	✔
T	✔		✔		
U	✔		✔		✔
V	✔		✔	✔	
W	✔		✔	✔	✔
X	✔	✔			

Y	✔	✔			✔
Z	✔	✔		✔	
[	✔	✔		✔	✔
\	✔	✔	✔		
]	✔	✔	✔		✔
^	✔	✔	✔	✔	
`	✔	✔	✔	✔	✔

When and absolute encoder is first set up the position (known as initialization position) it is at is always on the negative side of the reference marker pulse (Z). Below is a graphical example of how to use the serial information if it is a 1024 line (12-bit) absolute encoder:



Initialization Position:
This is the point where the absolute encoder was first set-up. The S-channel output for this point will be "P-00001,1003". To calculate how many pulses off of the marker pulse is then the following is done:

P-00001,1003 ➩(-1x4096)+1003=-3093
The encoder is 3093 ***unscaled*** quadrature pulses in the negative direction.

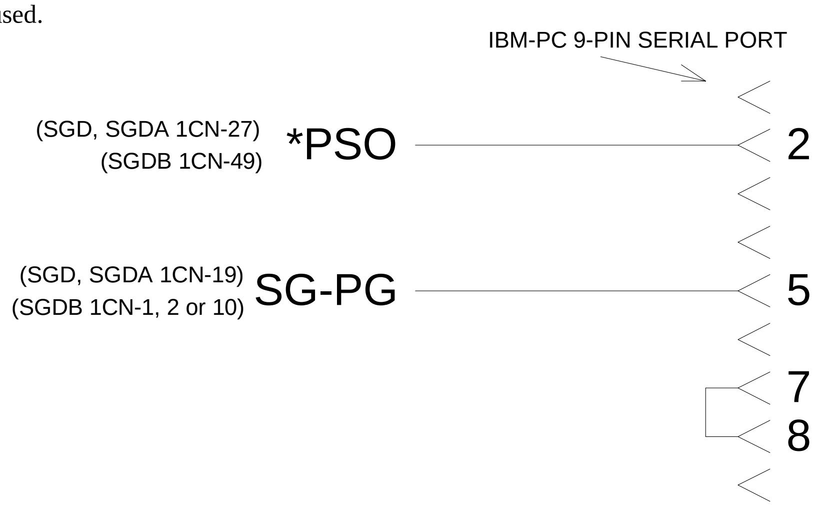
Current Position:

P+00001,3265➩(+1x4096)+3265=7361
The encoder is 7361 ***unscaled*** quadrature pulses in the positive direction.

Alarm Codes on Power-up:

Alarm Type	A-Channel Serial Data	S-Channel Serial Data
Backup Alarm	ALM81.<CR>	ALARMOABACK<CR>
Battery Alarm	ALM83.<CR>	ALARMODBATT<CR>
Checksum Error	ALM82.<CR>	ALARMOBCHEC<CR>
Overspeed	ALM85.<CR>	ALARMOPOVER<CR>
Absolute Error	ALM84.<CR>	ALARMOHABSO<CR>
Backup/Battery Combination Alarm	ALM81.<CR>	ALARMOEBACK<CR>

In order to monitor the S-channel using an IBM compatible PC's RS-232 port, the following connection should be used.



The following BASIC code works to capture S-channel information:

```
10 REM *****************************************************************
12 REM   THIS PROGRAM IS FOR A YASKAWA ABSOLUTE ENCODER'S S-CHANNEL.
14 REM   IT WILL CONTINUOUSLY READ THE ABSOLUTE DATA, CHANGE IT INTO
16 REM   SOMETHING USEFUL (NUMBER) AND PRINT IT TO THE SCREEN.
18 REM *****************************************************************
50 REM SET UP OF COM PORT AND OTHER STUFF
55 REM
100 STORED% = 0: REM MACHINE ZERO POSITION TO "0"
127 OPEN "COM1:9600,E,7,1,CD0,CS0,DS0,OP0,RS,TB2048,RB2048" FOR RANDOM AS #1: REM SETS UP COM#1
FOR S-CHANNEL OF ABSOLUTE ENCODER.
130 REM
135 REM ****************************************************
150 CLS
210 PRINT "HIT ANY KEY TO STOP PROGRAM"
215 PRINT "ABSOLUTE POSITION IS:"
217 GOSUB 1000
219 PRINT POSITION%;
220 B$ = INKEY$: IF LEN(B$) = 0 THEN 217
225 CLS
230 END
235 REM *****************************************************
300 REM
1000  REM THIS SUBROUTINE READS THE S-CHANNEL OF AN ABSOLUTE ENCODER
1005  LINE INPUT #1, A$
1007  IF LEN(A$) <> 12 THEN 1005
1010  STATUS$ = MID$(A$, 1, 1)
1015  ROTATION$ = MID$(A$, 2, 6)
1020  POSITION$ = MID$(A$, 9, 11)
1025  IF STATUS$ <> "P" THEN 2060: REM       TEST FOR AND ABSOLUTE ENCODER ALARM
2030  POSITION% = VAL(ROTATION$): REM         CONVERT & LOAD NUMBER OF ROTATIONS INTO VAR
2040  POSITION% = POSITION% * 4096: REM       MULTIPLY BY ENCODER RESOLUTION
2045  POSITION% = POSITION% + VAL(POSITION$): REM ADD THE POSTION WITHIN A REVOLUTION
2050  POSITION% = POSITION% - STORED%: REM     SUBTRACT MACHINE ZERO POSITION
2055  RETURN
2060 PRINT "ABSOLUTE ENCODER ALARM": END
```