



High-Resolution Absolute Position Encoders with the Ultra3000

Scope

This technical note applies to the following Allen-Bradley products:

- All 2098-DSD Ultra3000™ Digital Servo Drives
- MP-Series, H-Series (H6xxx and H8xxx) and 1326AB motors with Stegmann Sincos® Motor Feedback Systems for Servomotors, featuring Hiperface® (High Performance Interface)

Objective

This technical note provides information on applying high-resolution absolute position encoders with Ultra3000 Digital Servo Drives

Benefits of High Resolution Encoders

The use of high-resolution absolute position encoders provides many benefits over conventional A quad B incremental encoders:

- **Smart encoder technology** in the motor combined with auto-motor identification in the Ultra3000 offers a very user-friendly interface – on all platforms. The Ultra3000 automatically detects and configures the motor. Connect and Go!
- **High-resolution feedback** increases accuracy and provides more precise servo loop control:
 - A conventional 2000 line incremental encoder with A quad B circuitry provides only 8000 encoder counts per one revolution of the shaft.
 - The high-resolution encoder provides a coarse single turn resolution of 1024 sine/cosine cycles per revolution. This is further interpolated by the Ultra3000 to up to 1024 counts per cycle. The resulting product is 1024 x 1024 or 1,048,576 counts per revolution.

This is over 500 times the resolution of a conventional encoder!
- **The multi-turn** absolute encoder provides the ability to maintain absolute position even after power-down. The combination of the Ultra3000 and the Stegmann encoder has the ability to track absolute position very precisely. Because of the unique drive/motor combination, homing only needs to be performed once during commissioning of the system!

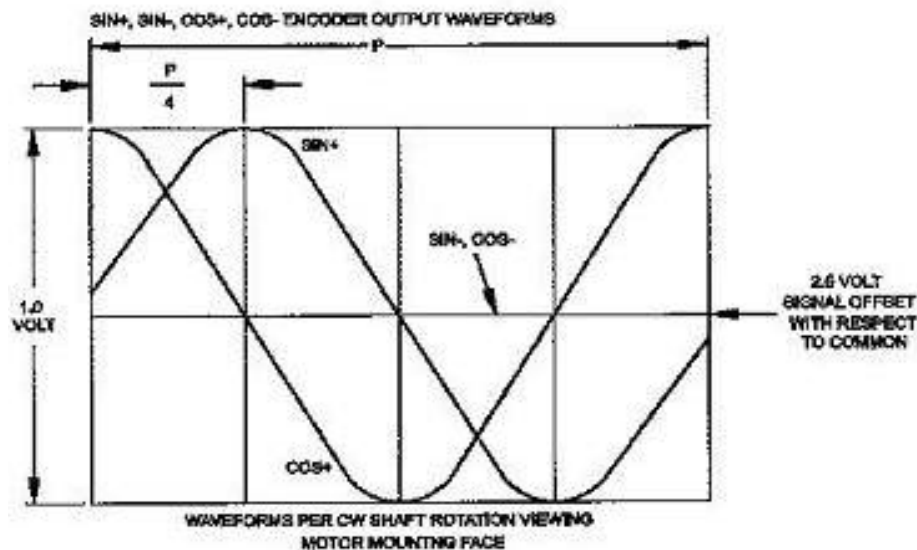
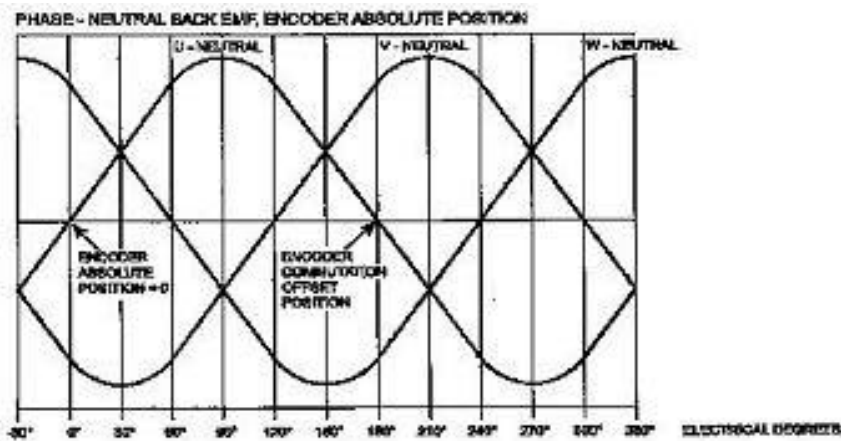
Auto-Motor Identification

The Stegmann encoders have an internal non-volatile memory. This allows information about the motor to be stored directly in the encoder. This area of memory contains the “blob file” as well as other information. Upon power-up, the Ultra3000 initiates a query to the encoder through the RS485 interface using the conventional index/marker channel. The motor information is sent from the encoder to the drive along with the absolute position. This is the only time that RS485 is used until the next power-up. Commutation information is derived from the encoder absolute position. There is no index (marker) pulse from the encoder. The Ultra3000 digitally synthesizes a marker pulse.

High-Resolution Encoder Signals

The High-resolution encoder produces a sine/cosine signal.

The voltage level of the sine/cosine is 2V to 3V with a reference of 2.5V.



The drive processes the signal through two different circuits:

- A digital A quad B receiver (the same as a standard A quad B encoder would use). Because the levels of the sine/cosine are within TTL specifications, they appear to the Ultra3000 as a standard A quad B digital signal with 1024 lines per revolution or 4098 counts per revolution. This determines the encoder's coarse position resolution.
- An analog circuit with two synchronously sampled A/D converters. Each converter processes a sine or cosine cycle. *The motor encoder interpolation is a user definable parameter in Ultraware™ under the encoder branch.* This determines the encoder's fine position resolution. The interpolation values available are x4, x8, x16, x32, x64, x128, x256, x512, or x1024 of each of the 1024 lines per revolution.

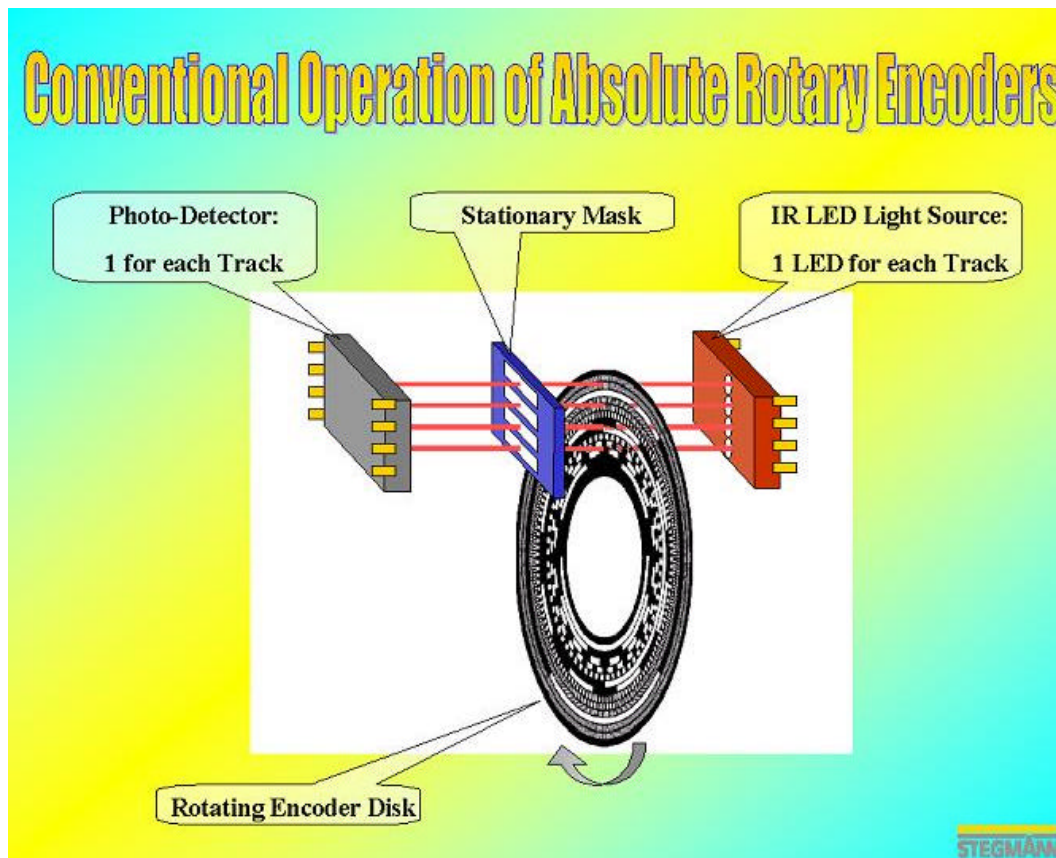
Deriving Absolute Position upon Initial Power-up (Commissioning) of the Ultra3000

The Stegmann multi-turn encoder has an absolute range of 4096 revolutions. The Ultra3000 uses a technique to extend this range. This range is further defined in the next section.

The high-resolution multi-turn encoder derives position information through a series of disks connected to the basic high-resolution disk through a system of gearing. Each additional disk provides a reduction for turn counting. Position data is available over multiple revolutions; in this case, 4096 revolutions. Upon power-up, the multi-turn position information is sent along with the coarse single turn position information.

The single revolution absolute position is derived through sensors on a glass encoder disk. The disk is etched with several concentric tracks, each consisting of a pattern of transparent and opaque segments. These independent tracks provide a unique combination of absolute values for each resolvable position. The coded format is a variation of Binary code called Gray code. This code will tell the drive which of the 1024 lines it is on at power-up. This gives the drive coarse position within one revolution. The Ultra3000 further interpolates the sine/cosine to derive a fine position.

This gives the ability to interpolate from $4 \times 1024 = 4098$ to $1024 \times 1024 = 1,048,576$ counts per revolution.



The Ultra3000 does not support any form of resolver based feedback devices

The Ultra3000 Maintains Absolute Position During Operation

Upon commissioning of the system, a home position must be defined. This can be done through a sensor or manually through Ultraware. Homing only needs to be performed once during commissioning

of the system. Homing needs to be repeated if the motor or Ultra3000 is replaced or reset to factory default.

Each time the Ultra3000 is powered-up it acquires the absolute position stored in the encoder. This position is added (or subtracted) to the absolute position that is stored in the Ultra3000 non-volatile memory. This sum is used by the Ultra3000 to derive absolute position.

After the power-up sequence, the encoder sine/cosine signals appear to the Ultra3000 as an incremental encoder with the added ability to interpolate at a higher resolution. The encoder absolute position is not read again until the drive is reset or power is cycled.

The Ultra3000 tracks incremental position on a real-time basis. The drive also tracks absolute position beyond the encoder's absolute range.

Limitations of Absolute Position

Two limitations exist relative to absolute position with the combination of the Ultra3000 and the Stegmann multi-turn encoder.

- During operation, once homed, the absolute position is $\pm 2^{31}$ or +2,147,483,648 to -2,147,483,648 counts from the defined home position. If this value is exceeded, the Ultra3000 will lose track of absolute position. The drive can be re-homed at any time within this window and absolute position will be maintained within +2,147,483,648 to -2,147,483,648 counts. While running in incremental mode any rollover is transient to the user but absolute position will be lost.
- After power-down the drive/motor combination can maintain absolute position within ± 1536 revolutions. With power removed, if the motor is moved beyond this distance and then moved back within this tolerance the Ultra3000 will recover absolute position. If this value is exceeded, the Ultra3000 will lose track of position upon the next power-up.

Connection of High-resolution encoders to the Ultra3000

The Ultra3000 has circuitry to support high-resolution Stegmann encoders.

This is available only for the motor encoder; it is not supported for the auxiliary encoder input. The following chart will explain a pin-out comparison of standard incremental encoders vs. high-resolution encoders:

<u>CN2 Pin</u>	<u>Description</u>	<u>Signal Name Incremental</u>	<u>Signal Name High-Resolution</u>	
1	Channel A+	AM+	SIN	
2	Channel A-	AM-	REFSIN	
3	Channel B+	BM+	COS	
4	Channel B-	BM-	REFCOS	
5	Channel I+	IM+	Data+	(RS 485)
10	Channel I-	IM-	Data-	(RS 485)
6	Common	ECOM	GND	
14	Encoder Power (+5V)	EPWR_5V	Us	5 V (230V motors)
7	Encoder Power (+9V)	N/A	Us	7-12V (460V motors)
11	Thermostat	TS	TS	
12	Commutation Channel S1	S1	N/A	
13	Commutation Channel S2	S2	N/A	
8	Commutation Channel S3	S3	N/A	
9	Positive Overtravel Limit	N/A	N/A	(Only used in linear motors)
15	Negative Overtravel Limit	N/A	N/A	(Only used in linear motors)

(N/A refers to Not Applicable)

Possible combinations of high-resolution encoders and Ultra3000 drives include:

The 230V Ultra3000 micro drives (2090-DSD-005, -010, and -020)

Provides 5V on CN2 - pin 14, CN2 – pin 7 is reserved

- 230V motors will function with the micro drives
- 460V motors will not function because 9V is needed to power the encoder

The 230V Ultra3000 standard drives (2090-DSD-030, -075, and -150)

Provides 5V on CN2 - pin 14, 9V on CN2 – pin 7

- 230V motors will function with the standard drives
- 460V motors will function with the standard drives but will be compromised on maximum speed depending on the K_E of the motor

The 460V Ultra3000 drive (2090-DSD-HV030, -HV050, -HV150, and -HV220)

Provides 5V on CN2 - pin 14, 9V on CN2 – pin 7

- 460V motors will function with the HV drives
- 230V motors will function with the HV drives (the drive must not be powered with over 230V or the drive will go into a fault condition)

For H-Series motors, 1326AB motors and further options refer to the Motion Control Selection Guide (GMC-SG001x-EN-P).

There are two options for high-resolution encoders

- Single turn high-resolution absolute encoder – Stegmann model SRS 50. Indicated by *S* in the feedback location of the motor part number – i.e.: MPL-A310P-SJ22AA. Currently, the Ultra3000 supports high resolution but not single turn absolute position
- Multi-turn high-resolution absolute encoder – Stegmann model SRM 50. Indicated by *M* in the feedback location of the motor part number – i.e.: MPL-A310P-MJ22AA. The Ultra3000 supports high-resolution and multi-turn absolute position

There are two different voltage high-resolution encoders depending on the drive voltage

The 230V motors use a 5V high-resolution encoder powered through CN2 - pin 14

A designates 230V in the motor part number – i.e.: MPL-A310P-MJ22AA

The 460V motors use a 7-12V high-resolution encoder powered through CN2 - pin 7

B designates 460V in the motor part number – i.e.: MPL-B310P-MJ22AA

One standard model of 2090 encoder cable will work with incremental, single turn, and multi-turn absolute encoders.

For more information on Stegmann encoders visit:

<http://www.stegmann.de/>

http://www.stegmann.de/pdf/Englisch/SRS5060_E.pdf

For more information on Allen-Bradley parts contact technical support at 262-512-8400. Before calling it is important to know the version of Ultraware and the firmware version of the Ultra3000 in use.

For more information refer to our web site: www.ab.com/motion

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