eXpert Ultrasonic NDT Position Encoder Firmware

Overview

Most ultrasonic nondestructive inspection systems are equipped with one or more position encoders, which accurately measure the position or angle of a scanning ultrasonic transducer or sample.

Although position encoders may operate with general purpose digitizers in ultrasonic inspection systems, digitizers equipped with encoder reading capability allow for the fastest possible scan rates.

Specifically, digitizers that can read encoders are able to overcome slow native encoder software interfaces and mitigate non-deterministic behavior in the Windows environment.

GaGe CompuScope digitizers that are equipped with position encoder reading capability addresses these modern ultrasonic inspection systems.

Position Encoder Types

Typical position encoders consist of a uniform sequence of optical or magnetic lines that are read by a sensor. Every time the sensor head moves past a line, the encoder output produces a pulse. For example, if the lines are spaced by 10 micrometers, then the encoder will output 100 pulses while it moves 1 mm. Similarly, if the head moves at a constant linear or rotational speed, its output becomes a square wave whose frequency is proportional to this speed.

In addition to measuring speed, most position encoders also indicate the direction of motion. The method used to indicate this direction defines two types of position encoders: Step & Direction encoders and Quadrature encoders.

Step & Direction encoders simply output a digital bit that indicates the direction of motion (e.g. 0 equals Left, 1 equals Right). Quadrature encoders indicate the direction of motion by the phase relationship between two square waves outputted by the encoder. In the diagram below, the fact that the Quadrature signal (Q) lags the In-phase signal (I) by 90° indicates that the encoder is traveling forwards. Backwards motion would cause Q to lead I by 90°.

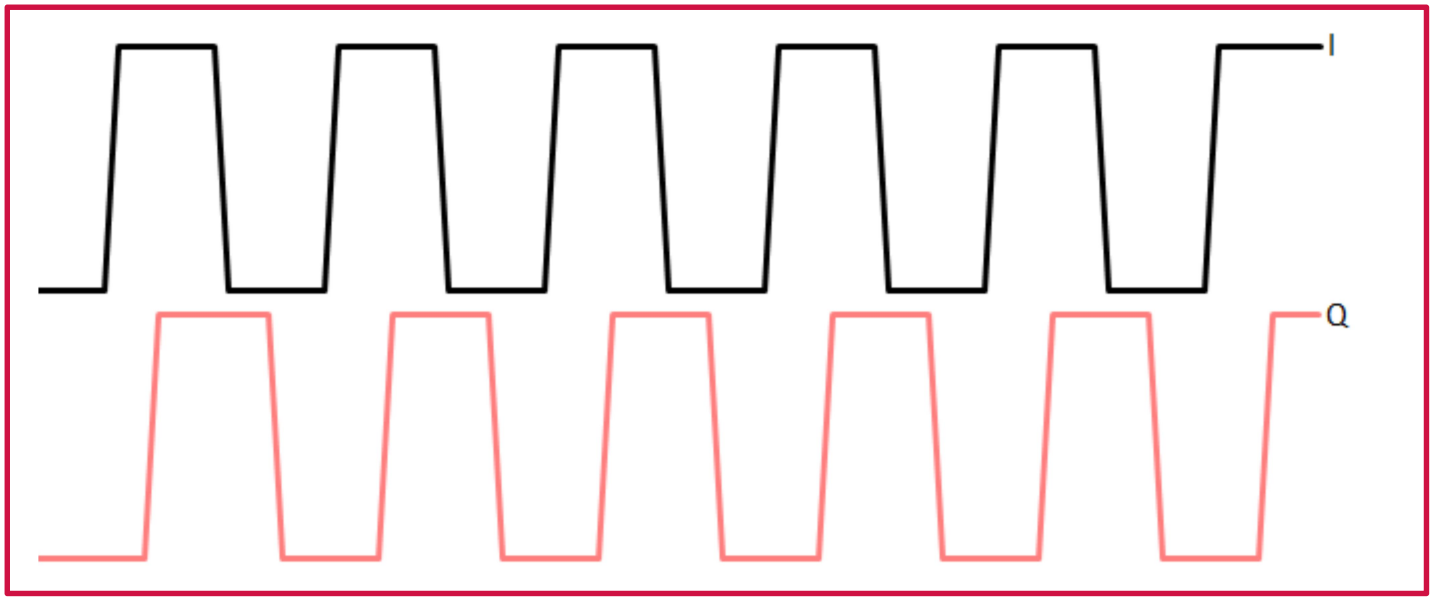


Figure 1: Phase Relationship of 2 Square Waves Outputted by Quadrature Encoders

Position Controllers

Position controllers that are used to position samples and ultrasonic transducers are usually equipped with internal position encoders. Information within this document regarding specifications for and operation of positioning controllers is used as a general guideline. Please check with the manufacturer of a specific position controller model to verify specifications and operation modes.

Three most popular positioning controllers used within the ultrasonic market include:

- Galil DMC-18x6: A PCI position encoder card. x=channel count. (www.galilmc.com)
- Galil DMC-40x0: A position encoder controlled through Ethernet or RS 232. x=channel count. (www.galilmc.com)
- Aerotech Soloist CL Series: A high end position encoding system. High output RF noise suppression. (www.aerotech.com)

The GaGe eXpert Ultrasonic NDT Position Encoder Firmware with the GaGe CompuScope digitizer encoder input fully supports these models. Please contact us for verification of compatibility with other possible manufacturer position controller models.

Encoders within position controllers may be located close to actuators in order to minimize such artifacts as backlash. This architecture provides for tight feedback but may not be ideal for positional accuracy. Accordingly, ultrasonic engineers often equip the scanning system with a separate additional "measurement only" encoder.

Although more costly, less elegant and perhaps less performant, a separate Counter/Timer may be used to process the position encoder signals. The National Instruments PCI-4601 Counter/Timer is often used for this purpose but is overkill because of its 20 MHz clocking rate and other unused features. However the specifications for the PCI-4601 can provide some guidance to engineers for these purposes.

Encoder Input

Due to the noisy industrial environments in which they operate, position encoder outputs are almost always differentially coupled. Accordingly, the GaGe CompuScope digitizer encoder input is also differentially coupled and so consists of two input connectors per encoder input. The input is high Z and supports TTL-type logic levels. Finally, while typical encoder frequencies are around 30 to 40 kHz, the GaGe CompuScope digitizer encoder input is capable of counting encoder signals with frequencies of up to 1 MHz.

CompuScope Digitizer eXpert Position Encoder

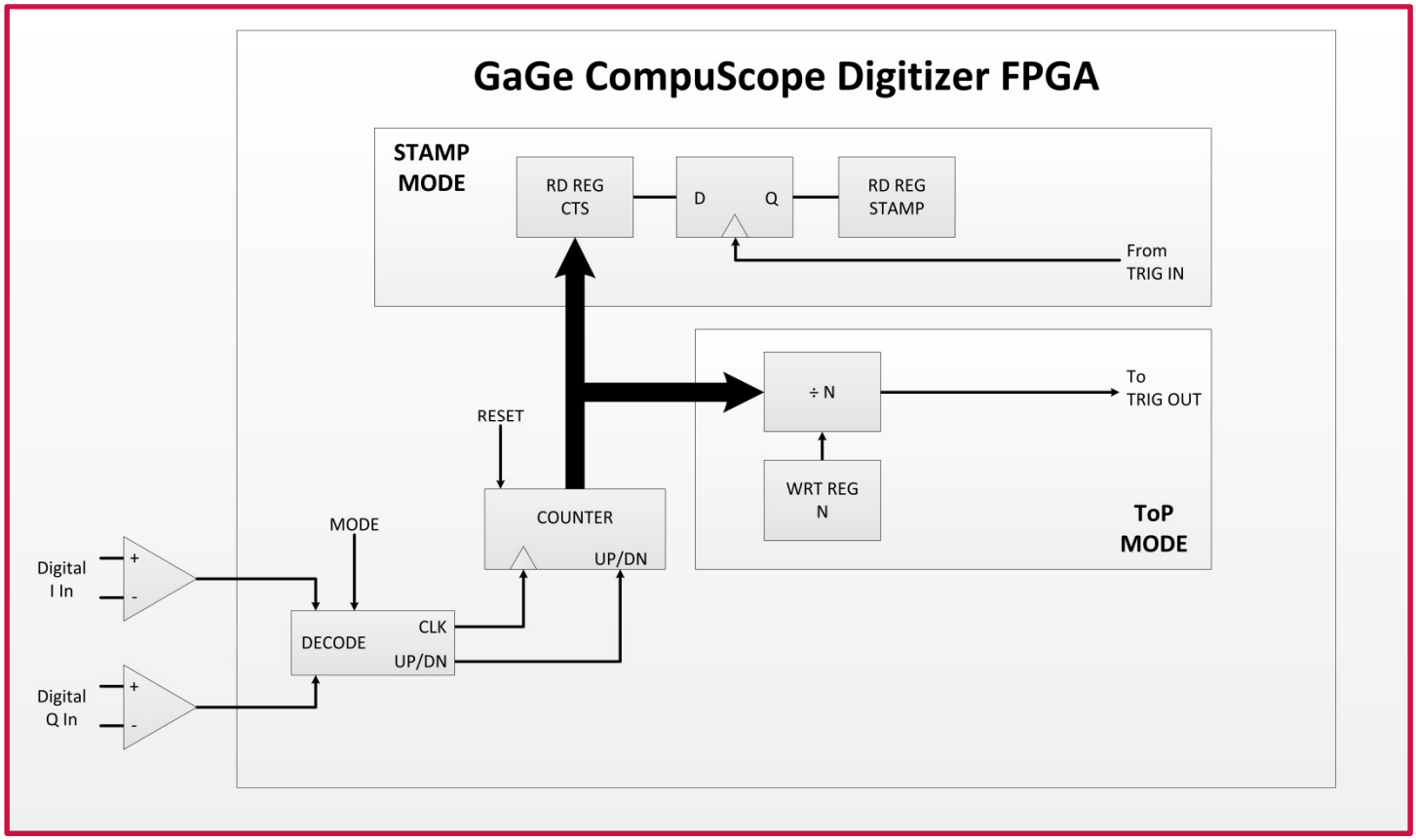
The block diagram below illustrates the required functionality for the CompuScope Digitizer eXpert Position Encoder Option. The two differential digital inputs that are required for digital position controllers are shown in the left of the diagram. The circuit is shown for Quadrature encoder signals, which are effectively turned into step & direction encoder signals by the Decode element. This element can be bypassed for Step & Direction signals. Only the two front end differential amplifiers are shown outside of the FPGA.

The output of the Decode element is passed to a counter element. The counter can sustain an account rate of up to 1 MHz. Furthermore, the counter is "on all the time", since if an encoder pulse is missed, all knowledge of the current head position is lost. Unlike the segmented ultrasonic acquisition, which incorporates significant dead time, the counter (once activated) must register and count all pulses that it sees regardless of the state of the high speed digitizer circuitry.

The eXpert Position Encoder firmware operates in two distinct modes: Pulse On Position (ToP) mode and Position Stamping mode. Generally speaking, Position Stamping mode is the more useful and less disruptive of the two modes.

In ToP mode, the counter output is first divided by a number passed by the user to the Write Register N. The output of the Div-by-N gate is 0 unless the input is divisible by N. The gate's output is routed as directly as possible to the Trigger Out output, with which the user will trigger an ultrasonic excitation. In this way, ultrasonic triggers are generated at the exact uniform positions that are separated by N position encoder steps.

In Position Stamping mode, the counter output value is passed to a Read Register called CTS (for "counts"), which the user will be able to read in order to monitor the position during setup. Next, the counter value enters a D Flip Flop that is clocked by the trigger pulse (or as direct as possible a copy of it). This way, the counter output, which indicates the head position, is latched at the exact moment when the trigger event occurs.



The CompuScope Digitizer eXpert Position Encoder Option provides two independent set of differential position encoder inputs. Normally, only one set of position encoder inputs is required for an ultrasonic scan. Two simultaneous encoder inputs are required, for example, in order to scan in a spiral pattern.

The low speed digital inputs signals enter the CompuScope Digitizer card through a ribbon cable that attaches to its FPGA. The other end of the ribbon cable attaches to an I/O slot panel plate equipped with a D-SUB connector to which signals are connected from the position encoder. The CompuScope Digitizer with the D-SUB connector bracket thus occupies a total of two I/O slots in the host system.

Application Software

The eXpert Ultrasonic NDT Position Encoder Firmware requires the GaGe C/C# SDK that provides a ready-made compiled encoder acquire sample program that illustrates the acquisition of multiple waveforms using both Pulse On Position (ToP) mode and Position Stamping mode and documentation for configuring encoder acquisition modes in C.

ORDERING INFORMATION

Model Number	Position Encoder Input Models	Order Part Number
CSE22G8PSN	Cobra Express PCIe Digitizer Card: 1 GS/s per CH, or 2 GS/s on 1-CH, 8-bit, 500 MHz BW, 2 GS (2 GB) Onboard Memory, with Position Encoder Input Hardware and Firmware supporting Trigger on Position and Position Stamping Modes **NOTE:** Requires GaGe C/C# SDK. Please refer to separate GaGe Cobra Express product data sheet for full digitizer specifications.	CBE-022-PSN

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Lockport, IL 60441-2200

Toll-Free (USA and Canada):
Phone: 1-800-567-4243
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www.gage-applied.com

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