Incremental Encoder Signal Analyzer

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Introduction

A motor encoder is a feedback device which can monitor and measure the motions of the motor shaft and is directly connected to the numerical system which controls the motor. Since the device lies in the feedback path, it plays a very important role in keeping the system up and going.

A maintenance team usually encounters breakdown issues wherein an encoder would be malfunctioning or failed down completely. An absence of a suitable analyzing device compatible of checking thorough healthiness creates the requirement of such device. The traditional method of using an oscilloscope for observing the pulses being inherently ambiguous, leads to incorrect decisions and increased breakdown time of the machine. Commercially, there are few devices available which can perform this function, but they are either too costly or under-featured.

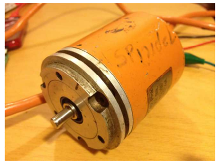


Figure 1. *A 1000 ppr Siemens encoder is used as a test piece. The encoder has two phase shifted channels A and B, a marker channel Z and their complements A', B' and Z'. The supply rating is 5VDC.*

Processing Core & IDE

A 8-bit, peripheral rich microcontroller, PIC18F4685 has been used at 20MHz to process the signals and derive the information. It has been developed on Microchip's integrated development environment MPLAB with a PICKit3 programmer and debugger.

The development system, EasyPIC v7 has been used which enables to exploit most of the hardware peripherals.

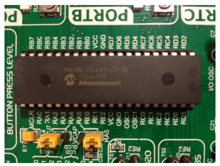


Figure 2. *The onboard 40 pin controller.*

HMI

The touch screen introduces operational versatility and reduces failure due to mechanical physical contact switches / buttons. The two dimensional coordinate stability is provided by a optional calibration cycle at the power-on event. The linearization is obtained by capturing 4 touch points.

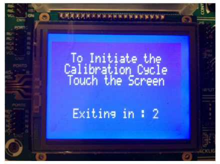
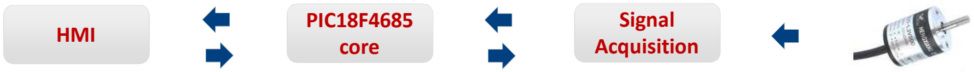


Figure 3. *A 128x64 pixel graphics LCD with 4 wire linear resistive touch screen overlay, used as HMI.*



Computations

PPR detection

The pulse per revolution is referenced at the marker channel and both the channels and their complements are checked.

DRO troubleshoot

Digital read outs are carried out for each channel and 'digital vector addition' between a channel and its complementary is done to detect missing pulse.

In absence of a complementary, the 'time-average calculation' detects the missing pulses – although the manual intervention imposes errors which have been minimized with filter 'ranges'.

Synchronization

Manual synchronization during re-assembly via referencing through Z and A / B channel readouts.

Duty & Phase Jitter

The amplitude digital vector addition with time averaging between A and B determines phase jitter and between of and off states of same channel determines duty jitter.

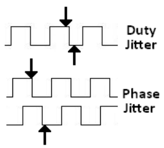


Figure 6. *Waveform Jitters*

Phase evaluation

Identification of marker channel w.r.t. pulse frequency and other channels wr.t. marker referencing

Direction Discriminator

A bit pattern of 11-01-00-10 is captured on a clock wise direction and 11-10-00-01 on a counter clock wise direction. Any other combination indicates a missing pulse; which is analyzed for its exact position on the next run after the marker reset.

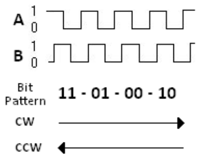


Figure 7. *Directional bit pattern*

Other Akin Computational Features:

- Resolution in terms of radians per pulse
- Signal level test - with ADC intervention. Output is in terms of percentage of V_{cc} level on encoder supply terminals.
- Complimentary channel check – after the integrity of a channel is confirmed by other tests, its complimentary is checked.

External Drive Computations (extensions):

- Systematic error – reproducible measuring deviation and its compensation factor.
- Reversal error – maturity of error on approaching from CW and CCW directions.
- Eccentricity error – finding out the lag in internal mechanical coupling in terms of shaft radians.

Signal Acquisition

The signals from the encoder channels have been isolated from microcontroller pins optically to avoid heavy sinking / sourcing on controller pins due to an internal fault in encoder. So, even though the acquired channel signals are inverted, it doesn't affect the analysis due to parallel symmetry on all channels.

The Optoisolators between the encoder and controller and provides a maximum switching delays of $t_{on} + t_{off}$ = 20µs

The analog short-circuit protection stage facilitates detection of internal faults in the encoder and maintains a disturbance free voltage at pre-encoder stages.

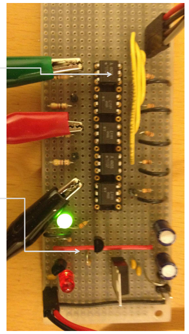


Figure 4. *The signal acquisition block*

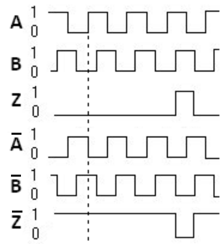


Figure 5. *The inverted signal pattern of encoder.*

For Further Information

Please contact for this project at pp423@cornell.edu.
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