Interfacing Quadrature Encoders Using the High-End Timer on Hercules MCUs

Sunil Oak

ABSTRACT

The next-generation high-end timer module (HET) on Hercules MCUs is an intelligent timer that provides sophisticated timing functions for real-time applications. The timer is an independent coprocessor, using its own reduced instruction set, with a specialized timer micromachine and an attached I/O port. The HET can be used for generating pulse-width-modulated outputs, for capturing or comparing inputs, or for general-purpose I/O (GPIO). The programmable nature of the HET allows it to be used to implement several kinds of interfaces. This application report describes an implementation of a quadrature decoder using the HET module. This allows you the flexibility to interface to one or more quadrature encoders, thereby, allowing you to design a closed-loop sensored motor-control algorithm using a position/direction/speed sensor.

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1 Introduction

Quadrature encoders are a type of incremental encoders. These provide cyclical outputs when the encoder is rotated. They can be mechanical, optical or magnetic. Optical quadrature encoders are used when higher speeds are required or a higher degree of precision is required.

Quadrature encoders have two main outputs: QEPA and QEPB. These are 90° out of phase, therefore, the name quadrature outputs.

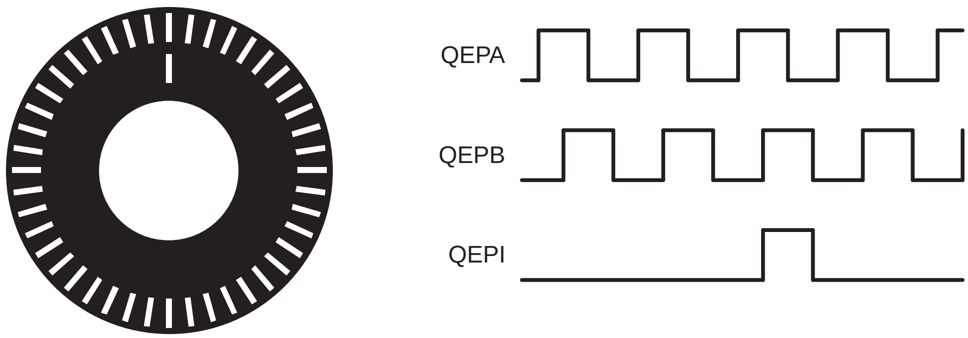
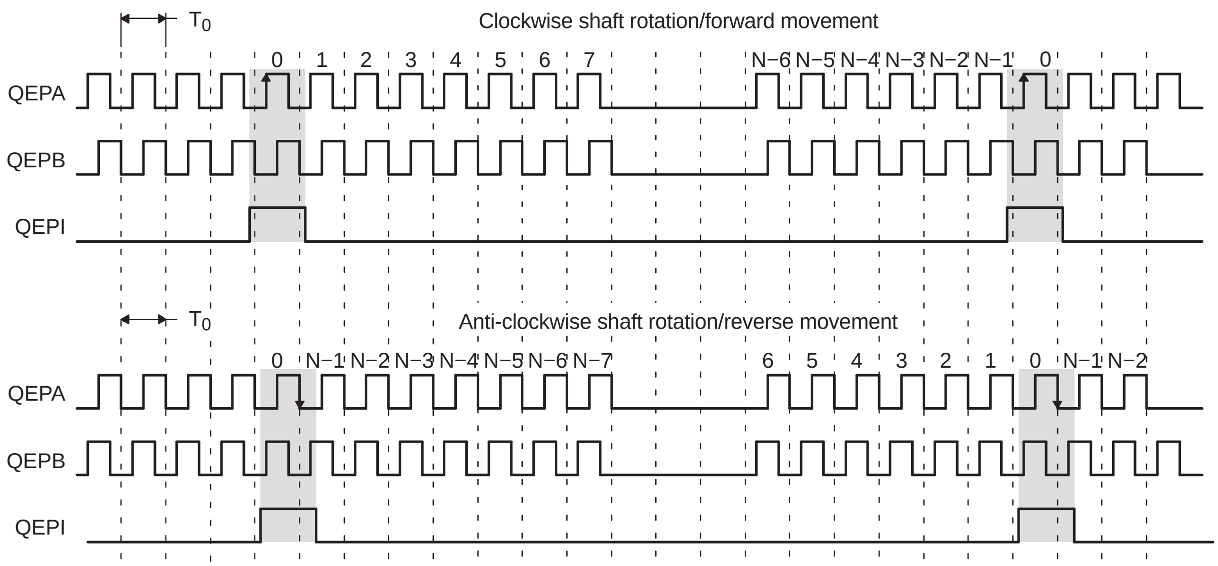


Figure 1. Optical Encoder Disk

The two outputs QEPA and QEPB are decoded to count up or down depending on the direction of movement. Some encoders have an additional output, named QEPI. This is an "index" marker that occurs once every rotation. This marker is used as an accurate reference point.



Legend: N = lines per revolution

Figure 2. Encoder Output Signals for Forward and Reverse Movement

The encoder wheel typically makes one revolution for every revolution of the motor, or the wheel may be at a geared rotation ratio with respect to the motor. Therefore, the frequency of the digital signal coming from the QEPA and QEPB outputs varies proportionally with the speed of rotation of the motor. For example, a 2000-line encoder directly coupled to a motor running at 5000 revolutions per minute (rpm) results in a QEPA/QEPB signal frequency of 166.67 kHz. So by measuring the frequency of either QEPA or QEPB, the MCU can determine the velocity of the motor.

2 HET Implementation of Quadrature Decoding

This document describes the implementation of a quadrature decoder using the high-end timer (HET) module on Hercules MCUs.

2.1 Quadrature Decoder State Diagram

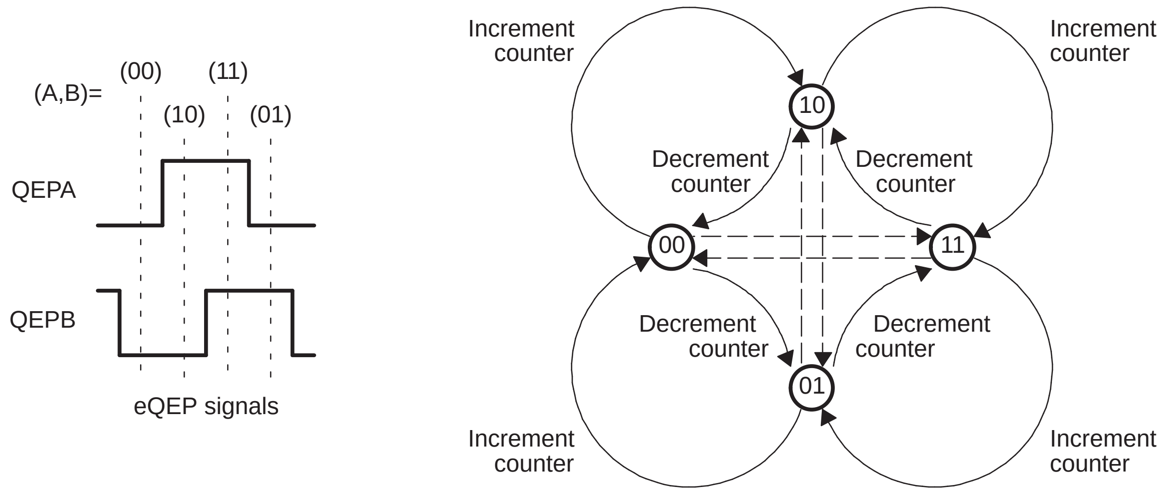


Figure 3. Quadrature Decoder State Machine

Figure 3 shows the quadrature decoder state machine implemented using the HET. The HET program determines which one of the inputs, QEPA or QEPB, is leading and accordingly increments or decrements a counter. The QEPI (index) pulse is used to reset the counter to zero on each rotation of the encoder.

2.2 HET Program for Implementing Quadrature Decoder State Machine

```
Pin_A     .equ  0       ; Signal A from QEP encoder
Pin_B     .equ  1       ; Signal B from QEP encoder
INDEX     .equ  2       ; Index from QEP encoder

;---------------------------INDEX-CLR Counter ---------------------------------
START     ECNT    { next = AFE, cond_addr = CLRCNT, event = Fall, pin = INDEX, reg = NONE, data =
0}

CLRCNT    MOV32   { next = AFE, remote = FOR, type = IMTOREG&REM, reg = A, Data = 0}

;---------------------------check: aFbL  /   aFbH ------------------------------

AFE       BR      { next = ARE, cond_addr = AFL, event = Fall, pin = Pin_A}

AFL       BR      { next =  FOR, cond_addr = BAC, event = Low, pin = Pin_B}

;---------------------------check: aRbL  /   aRbH ------------------------------

ARE       BR      { next = BFE, cond_addr = ARL, event = rise, pin = Pin_A}

ARL       BR      { next = FOR, cond_addr = BAC, event = high, pin = Pin_B}

;---------------------------check: bFaL  /   bFaH ------------------------------

BFE       BR      { next = BRE, cond_addr = BFL, event = Fall, pin = Pin_B}

BFL       BR      { next = FOR, cond_addr = BAC, event = high, pin = Pin_A}

;---------------------------check: bRaL  /   bRaH ------------------------------

BRE       BR      { next = START, cond_addr = BRL, event = rise, pin = Pin_B}

BRL       BR      { next = FOR, cond_addr = BAC, event = low, pin = Pin_A}

;--------------------------------------------------------------------------------

FOR       CNT     { next = START, reg = NONE, max = 0x0FA0}

;--------------------------------------------------------------------------------

BAC       MOV32   { next = LIM, remote = FOR, type = REMTOREG, reg = A}

LIM       ECMP    { next = SSUB, cond_addr= HIL, hr_lr=LOW, en_pin_action=off, pin=CC0, reg= A,
data=0}

HIL       ADM32   { next = START, remote = FOR, type = IM<REGTOREM, reg = A, data = 0x0000FA0}

SSUB      ADM32   { next = START, remote = FOR, type = IM<REGTOREM, reg = A, data = 0x1FFFFFF}
```

2.2.1 Accessing Position Counter Information

The data field of the HET instruction labeled FOR can be read to determine the current count and therefore the current position of the rotor position with respect to the last index pulse. Refer to the high-end-time module chapter of the part's technical reference manual for more details.

References

- *HET Integrated Development Environment Users' Guide* (SPNU483)
- NHET Getting Started (SPRABA0)
- *RM46x 16/32-Bit RISC Flash Microcontroller Technical Reference Manual* (SPNU514)

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